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BASIC RESEARCH AND DATA ANALYSIS FOR THE EARTH AND OCEAN PHYSICS APPLICATIONS PROGRAM AND FOR THE NATIONAL GEODETIC SATELLITE PROGRAM

Third Semiannual Status Report
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PREFACE

These projects are under the supervision of Professor Ivan I. Mueller, Department of Geodetic Science, The Ohio State University, and are under the technical direction of Mr. James P. Murphy, Special Programs, Office of Applications, NASA Headquarters, Washington, D. C. The contracts are administered by the Office of University Affairs, NASA Headquarters, Washington, D. C. 20546.

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1. STATEMENT OF WORK

The statement of work includes data analysis and supporting research in connection with the following broad objectives:

(1) Provide a precise and accurate geometric description of the earth's surface.

(2) Provide a precise and accurate mathematical description of the earth's gravitational field.

(3) Determine time variations of the geometry of the ocean surface, the solid earth, the gravity field, and other geophysical parameters.

2. ACTIVITIES RELATED TO THE NGSP
(Grant No. NGL 36-008-093)

2.1 Data Acquisition and Processing

An updated position regarding the acquisition and processing of the data of the ISAGEX and WEST programs is given below.

2.11 WEST Data

The unified optical observation program, now known as WEST (Western European Satellite Triangulation), was begun in 1966. The program was conducted by a subcommittee of the IAG (International Association of Geodesy). The program was formally terminated in 1972 (Resolution No. 1, Sixth Meeting of the Subcommittee in 1972). During the program approximately 3,500 simultaneous plates were acquired.

The Department of Geodetic Science is examining the possibility of including data from the WEST campaign in the OSU WN-14 worldwide solution for two reasons: firstly, to strengthen station coordinates which are presently included in WN-14; and secondly, to add selected new stations where appropriate.

The WEST data was given to OSU in two forms. The first form consisted of cards in two sets. One set contained the direction cosines, referred to the Greenwich Hour Angle/Declination coordinate system, for single fictitious images for each plate for all simultaneous events. The other set contained information on the standard errors associated with the direction data. The second form contained the direction cosines of seven fictitious events for each plate for all simultaneous events. No specific information concerning the precision of this data was received although some information was derived from the earlier data.

All data was transcribed to magnetic tape and is listed below:

<u>Tape Name</u>	<u>WN0002</u>
DCB characteristics	RECFM = FB, LRECL = 80, BLKSIZE = 8000
File No. 1	Single image direction cosines

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File No. 2	Standard errors associated with single images
File No. 3	Seven image direction cosines

Steps were taken to use the single image data when it arrived. OSU did not hold any program which could reduce this type of data at first, but another program (OSUGOP) used for similar data was modified. Previously OSUGOP had been used to reduce the BC-4 seven image data and was later modified by Dr. J. P. Reilly to accept single image observations. By the time of this last mentioned modification, however, the seven-image data had been received, hence there are no further intentions of pursuing this aspect of the computations.

The WEST data will eventually be added to the WN-14 solution by combination of normal equations. In order to generate these and assess the internal consistency of the data, closed figures will need to be identified. These will then be computed as an independent network. Residuals and standard errors at the stations will indicate the quality of the data. Since all data has been preprocessed in a consistent manner, it should be of high quality.

During the WEST campaign a series of bulletins was distributed which documented the current status of the operation and also gave information concerning the definition of the participating stations, coordinates, movements, etc. To eliminate some of the confusion an attempt has been made to identify all stations in WEST, ISAGEX and the WN-14 net which are identical and then obtain ties between the remaining stations which are in close proximity and have been connected. Correspondence was initiated with Mr. Gunther of Computer Sciences Corporation in this regard. It is not expected, however, that the problem will ever be completely resolved.

2.12 ISAGEX Data

The Centre National d'Etudes Spatiales has provided OSU with data

acquired during the ISAGEX satellite observation compaign. The data consists of 5,186 laser ranges and 3,562 optical observations which were purported to be simultaneous. The intention behind the acquisition of this data was to examine its suitability for inclusion (either in whole or in part) in the OSU WN-14 solution which contains some unacceptably large uncertainties in the area of Western Europe. Because most of these stations had participated in the ISAGEX campaign, it was expected that their uncertainties could be reduced.

A number of dynamic solutions have been made by other agencies using both optical and laser data from ISAGEX. The interest at OSU was to make solutions in the geometric mode.

The laser data was examined for simultaneity by computing the observation times at the satellite in International Atomic Time for all data. These times were then examined for simultaneity. The OSU program GEOMSG which was to have been used for the solution, defines simultaneity in terms of a discrepancy of 0.2 ms. Using this definition no simultaneous observations were detected.

Examination of the optical data was more complicated. The first test was to discover the amount of data which was simultaneous by using the above criterion. This would show whether further processing was warranted. A wider definition of simultaneity was used to accomodate possible variations in observation times which would arise from preprocessing. Approximately 10% of the data satisfied the test, indicating that further examination was warranted.

The requirements for preprocessing were considered. The ISAGEX Data Handling Booklet, No. 16 [April, 1973] provided most of the information required; and other data was extracted from the remaining ISAGEX publications. A summary of the information extracted can be seen in the attached table. The summary indicated that preprocessing by OSU was possible but not practical due to limited resources. Wolf Research and Development Corp. offered to undertake preprocessing of the data using their GEODYN program, suitably modified. The offer was accepted.

Observations made on satellites GEOS I, GEOS II, DIADEME-C and DIADEME-D were preprocessed initially because their orbital elements were available at Wolf for the observational period. Elements for MIDAS and PAGEOS were later provided by SAO.

The preprocessed data was then tested for simultaneity and a total of 353 observations proved satisfactory. Before including the data in the WN-14 solution it was to be tested for acceptable quality. The test was to consist of performing solutions using only ISAGEX simultaneous data. If the data was satisfactory the normal equations so generated were to be added to the WN-14 solution directly.

Of the simultaneous data, only observations between stations 1147, 8009, 8010, 8034 and 9004 formed a closed net. Consequently the data from these stations was extracted and a number of solution runs were made. Very large residuals resulted even after a number of iterations. The constraints imposed were as follows:

"inner" constraint

station coordinates for 8010

chord distance for the line 8010 - 9006

station heights for all stations.

Station heights were found by adding levelled heights to geoidal undulations computed for the stations under consideration.

Station 1147 showed very large residuals and was removed; then the solution was repeated. Variances and weights were altered in accordance with the estimated variance of an observation of unit weight. Although the residuals were greatly reduced, they remained unacceptably large. Furthermore the variances of the resulting station coordinates were also very large. The residuals were tabulated and compared with those from the current WN-14 solution and were found to be larger by a factor of about 100.

The position will be re-examined on receipt of preprocessed data for MIDAS 4 and PAGEOS from Wolf Research & Development Corp.

A summary of the status of ISAGEX data held at OSU is given in Attachment 1. A summary of the preprocessing in respect to the data held at CNES is given in Attachment 2.

Status of ISAGEX Data Held at OSU

CNES has sent three sets of printouts containing ISAGEX observations data:

a. The first set is dated September 1973.

b. The second set is dated December 1973 and was accompanied by a magnetic tape on which the data was recorded. The tape has been retained. A listing of simultaneous observations was also included. Tape is numbered No. 1.

c. The third set is dated April 1974 and was accompanied by a magnetic tape on which the data was recorded. The tape has been retained. This is Tape No. 2 and is the revised version of Tape No. 1.

Note that CNES tapes are written in 7 track, 556 bpi, even parity, the characteristics of which are given below:

The data is held in both cards and card images on magnetic tape.

TAPES:

Tape No. 1 and Tape No. 2 have been received from CNES.

Tape No. 2 has been designated ID WN0004.

We have an additional tape, ID WN0003.

The revised Tape No. 2 that was received from CNES, contains both laser and optical ISAGEX data current as of February 1974. The tape was written with the following characteristics:

Seven tracks
Even parity
556 bpi
Record length 80

Block size 80
Tape ID WN0004
Tape No. 2.

The data has been transcribed in identical format onto OSU tape with the following characteristics:

Nine tracks
Odd parity
800 bpi
Record length 80
Block size 8000
Tape ID WN0003
Label=(,BLP).

<u>File No. 1</u> Laser data. Unaltered. 5186 records. Most recent data, raw format.

<u>File No. 2</u> Optical data. Unaltered. 3562 records. Most recent data, raw format.

<u>File No. 3</u> Both laser and optical combined. Reformatted as follows:

<u>Laser Section</u>

Column	Characters	
1	1	Quality index
2	2	Year
4	2	Month
6	2	Day
8	11	Time - hours, min, sec
19	4	Station number
23	6	Satellite number
29	10	Range
39	7	Synchronization
46	4	Time scale
50	7	Time to UT1
57	1	Timing accuracy index
58	4	Range correction
62	4	Pressure
66	3	Range correction index
69	5	Orbit number
74	3	Temperature
77	3	Relative humidit
80	1	Observation type

Optical Section

Column	Characters	
1	1	Quality index
2	2	Year
4	2	Month
6	2	Day
8	11	Time - hours, min, sec
19	4	Station number
23	6	Satellite number
29	5	Film number
34	9	Right ascension
43	9	Declination
52		BLANK
53	3	Timing accuracy
56	1	Index for observation type
57	1	Reference system index
58	1	Camera type
59	7	Time scale correction
66	5	Correction to UT1
71	6	Observation accuracy
77	3	Time scale code

File No. 4 As for No. 3, but in chronological sequence (by raw time).

File No. 5 Optical data in chronological sequence (in UT1) in original CNES format.

CARDS:

Data set A — ISAGEX optical in chronological sequence. All observations have been reduced to the same time scale (UT1). Not preprocessed (File No. 5).

Data set B — ISAGEX laser in chronological sequence. All observations have been reduced to the same time scale (UT1), at the satellite, at the instant of reflection.

Data set C — ISAGEX optical, preprocessed, arranged in chronological sequence.

Data set D — ISAGEX optical, preprocessed, as received.

Summary of Data Preprocessing as Held at CNES

Agency/Station	SAO	GRGS	ASTRO-SOVJET	ONDREJOV/ POTSDAM	BRITISH	DUTCH	SWISS
Coordinate System	Mean, 1950.0	Mean, 1950.0	Mean, 1950.0	True of date	True of date	Mean, 1950.0	Mean, 1950.0
Corrected for Diurnal Aberration	No	No	No	Yes	Yes	No	No
Corrected for Parallactic Refraction	No	No	No	1181 only	Yes	No	No
Time Given	At plate	At plate	Flash and at plate	Flash and at plate	Flash	Flash	Flash
Corrected for Annual Aberration	Yes	No	No	Yes	Yes	No	Yes
Mode of Observation	Stationary	Dakar Tracking 8019 Sidereal	Sidereal Tracking		Stationary		Sidereal Tracking
Mode Correction Applied	Yes	No	N/A	Not known	Not known	Not known	Not known
Time Scale Used	AS	Passive Station Clock	Passive UT1(USSR)	Passive, UTC			

All active observations recorded as GEOS-2 flash times.

2.2 Determination of Transformation Parameters

2.21 Modification of the Veis-model

Subsequent to inclusion of transformation modes [section 2.21 of the Fourteenth Semiannual Status Report of OSURF, Project No. 3820 A-1, January through June 1974], our program was modified to obtain Veis's model rotation angles from Molodensky's angles which have been obtained directly from direction cosines.

If ω, ψ, ϵ and dA, $d\xi$, $d\eta$ are the respective angles of Molodensky's and Veis's models, from Equation 3 of the above quoted reference,

$$\begin{bmatrix} dA \\ d\xi \\ d\eta \end{bmatrix} = \begin{bmatrix} \sin\varphi_0 & \cos\varphi_0 \sin\lambda_0 & \cos\lambda_0 \\ 0 & \cos\lambda_0 & -\sin\lambda_0 \\ -\cos\varphi_0 & \sin\varphi_0 \sin\lambda_0 & \cos\lambda_0 \end{bmatrix} \begin{bmatrix} \omega \\ \psi \\ \epsilon \end{bmatrix} \tag{1}$$

Further, applying the principle of propagation of errors,

$$\Sigma_{dA\,d\xi\,d\eta} = G \; \Sigma_{\omega\psi\epsilon} \; G', \tag{2}$$

where

$\Sigma_{dA\,d\eta\,d\xi}$ is the variance-covariance matrix for dA, $d\eta$, $d\xi$,

$\Sigma_{\omega\psi\epsilon}$ is the variance-covariance matrix for ω, ψ, ϵ.

$$G = \begin{bmatrix} \sin\varphi_0 & \cos\varphi_0 \sin\lambda_0 & \cos\varphi_0 \cos\lambda_0 \\ 0 & \cos\lambda_0 & -\sin\lambda_0 \\ -\cos\varphi_0 & \sin\varphi_0 \sin\lambda_0 & \sin\varphi_0 \cos\lambda_0 \end{bmatrix}$$

The information vide equation (1) and (2) above can then be used as weighted constraints in our standard seven parameter solutions. Earlier Veis-model solutions were without these constaints.

The above modification was then used to obtain fresh solutions in respect of four major datums viz North American, European, South American and Australian— superseding Tables 2.2-2, 2.2-5, 2.2-9 and 2.2-11 of the reference quoted above.

The results are given below:

A. Australian → WN14 (Table 2.2-1)

B. European 50 → WN14 (Table 2.2-2)

C. North American 27 → WN14 (Table 2.2-3)

D. South American 1969 → WN14 (Table 2.2-4)

A summary of the results is presented in Table 2.2-5, which supersedes the corresponding results in Table 2.2-12 of the Fourteenth Semi-annual Status Report.

2.22 The Vanicek-model

A new model for correlating geodetic datums with satellite systems was presented at the International Symposium on Problems Related to the Redefinition of North American Geodetic Networks, May 20-25, 1974, Fredericton, N.B., Canada by P. Vanicek. The salient features of the model are:

(a) The fundamental system for reference is taken as the Average Terrestrial System (ATS).

(b) The satellite system is assumed to have the same origin as ATS but not the same orientation, i.e., three rotation angles (ω, ψ, ϵ) would be needed to bring it in the ATS system.

(c) Any geodetic datum is related to ATS through three translations, one scale and one orientation parameter. In this model Vanicek showed that a geodetic datum can be made parallel with ATS by means of a single rotation (Δ) about the ellipsoidal normal at the origin point of the datum.

Table 2.2-5

Summary of Datum Transformations to WN-14 System

Transformation Model	Datum	Australian National		ED-50		NAD-27		SAO-69	
		4 Parameters	7 Parameters	4 Parameters	7 Parameters	4 Parameters.	7 Parameters	4 Parameters	7 Parameters
Vcis	Δu		-157.0± 1.8		- 99.4± 4.4		- 31.7± 1.4		- 96.6± 3.0
	Δv		- 59.1± 1.8		-132.0± 4.5		142.3± 1.3		- 13.7± 3.0
	Δw		131.2± 2.0		-116.0± 4.3		177.3± 1.2		- 29.4± 3.2
	$\Delta_{*10^{-6}}$		1.20± 0.71		6.75± 0.84		- 0.80± 0.27		- 6.67± 0.59
	ω''		- 0.35± 0.14		0.51± 0.21		- 0.33± 0.05		- 0.02± 0.11
	ψ''		0.49± 0.24		- 0.25± 0.33		- 0.29± 0.10		- 0.03± 0.13
	ϵ''		1.31± 0.19		0.15± 0.21		0.84± 0.06		- 0.66± 0.17

Table 2.2-1

Australian National to WN-14 (Veis Model)

DU METERS	DV METERS	DW METERS	DELTA (X1.D+6)	ALPHA SECONDS	KSI SECONDS	ETA SECONDS
-156.97	-59.14	131.23	1.20	-0.35	0.49	1.31
± 1.85	± 1.82	± 2.03	± 0.71	± 0.14	± 0.24	± 0.19

VARIANCE - COVARIANCE MATRIX

SO2= 0.48

0.341D+01	0.615D-02	0.258D-01	0.511D-07	0.383D-08	-0.255D-07	-0.264D-06
0.615D-02	0.331D+01	0.444D-01	0.172D-06	0.818D-07	0.217D-06	-0.537D-07
0.258D-01	0.444D-01	0.410D+01	-0.903D-07	0.141D-06	0.319D-06	-0.219D-06
0.511D-07	0.172D-06	-0.903D-07	0.507D-12	-0.880D-14	0.139D-13	0.556D-15
0.383D-08	0.818D-07	0.141D-06	-0.880D-14	0.461D-12	-0.176D-13	-0.234D-13
-0.255D-07	0.217D-06	0.319D-06	0.139D-13	-0.176D-13	0.134D-11	-0.435D-12
-0.264D-06	-0.537D-07	-0.219D-06	0.556D-15	-0.234D-13	-0.435D-12	0.859D-12

COEFFICIENTS OF CORRELATION

0.100D+01	0.183D-02	0.690D-02	0.389D-01	0.305D-02	-0.119D-01	-0.154D+00
0.183D-02	0.100D+01	0.120D-01	0.133D+00	0.662D-01	0.103D+00	-0.319D-01
0.690D-02	0.120D-01	0.100D+01	-0.626D-01	0.102D+00	0.136D+00	-0.117D+00
0.389D-01	0.133D+00	-0.626D-01	0.100D+01	-0.182D-01	0.169D-01	0.843D-03
0.305D-02	0.662D-01	0.102D+00	-0.182D-01	0.100D+01	-0.224D-01	-0.371D-01
-0.119D-01	0.103D+00	0.136D+00	0.169D-01	-0.224D-01	0.100D+01	-0.406D+00
-0.154D+00	-0.319D-01	-0.117D+00	0.843D-03	-0.371D-01	-0.406D+00	0.100D+01

NOTE : THE POSITIVE ROTATIONS ARE TOWARDS SOUTH

EAST , AND ALONG ELLIPSOIDAL NORMAL UPWARDS.

Note: Scale factor and rotation parameters constrained.

Table 2.2-1 (Continued)

RESIDUALS V

	V1(AUS.NAT.)				V2(WN- 14)			V1 - V2		
6023	0.9	-0.4	-2.9	6023	-0.8	0.4	1.8	1.7	-0.8	-4.8
6032	1.0	1.2	0.7	6032	-0.9	-1.2	-0.5	2.0	2.4	1.2
6060	-1.9	-0.8	1.9	6060	1.8	0.7	-1.4	-3.7	-1.5	3.2

UNIT OF RESIDUALS (METERS)

Table 2.2-2

ED-50 to WN-14 (Veis Model)

DU METERS	DV METERS	DW METERS	DELTA (X1.D+6)	ALPHA SECONDS	KSI SECONDS	ETA SECONDS
-99.43	-132.00	-115.98	6.75	0.51	-0.25	0.15
± 4.39	± 4.54	± 4.34	± 0.84	± 0.21	± 0.33	± 0.21

VARIANCE - COVARIANCE MATRIX

SO2= 1.03

0.193D+02	0.187D+00	0.172D+00	-0.153D-06	0.122D-06	-0.106D-05	-0.722D-08
0.187D+00	0.206D+02	0.100D+00	-0.129D-06	0.479D-06	-0.531D-06	0.248D-06
0.172D+00	0.100D+00	0.188D+02	0.316D-06	0.189D-06	-0.611D-06	0.667D-07
-0.153D-06	-0.129D-06	0.316D-06	0.700D-12	-0.149D-14	-0.108D-15	0.808D-15
0.122D-06	0.479D-06	0.189D-06	-0.149D-14	0.102D-11	-0.631D-12	-0.226D-13
-0.106D-05	-0.531D-06	-0.611D-06	-0.108D-15	-0.631D-12	0.261D-11	-0.289D-15
-0.722D-08	0.248D-06	0.667D-07	0.808D-15	-0.226D-13	-0.289D-15	0.104D-11

COEFFICIENTS OF CORRELATION

0.100D+01	0.936D-02	0.901D-02	-0.417D-01	0.276D-01	-0.149D+00	-0.161D-02
0.936D-02	0.100D+01	0.508D-02	-0.339D-01	0.105D+00	-0.724D-01	0.537D-01
0.901D-02	0.508D-02	0.100D+01	0.870D-01	0.432D-01	-0.873D-01	0.151D-01
-0.417D-01	-0.339D-01	0.870D-01	0.100D+01	-0.177D-02	-0.801D-04	0.948D-03
0.276D-01	0.105D+00	0.432D-01	-0.177D-02	0.100D+01	-0.387D+00	-0.220D-01
-0.149D+00	-0.724D-01	-0.873D-01	-0.801D-04	-0.387D+00	0.100D+01	-0.176D-03
-0.161D-02	0.537D-01	0.151D-01	0.948D-03	-0.220D-01	-0.176D-03	0.100D+01

NOTE : THE POSITIVE ROTATIONS ARE TOWARDS SOUTH EAST , AND ALONG ELLIPSOIDAL NORMAL UPWARDS.

Note: Scale factor and rotation parameters constrained.

Table 2.2-2 (Continued)

RESIDUALS V

	V1(ED- 50)				V2(WN- 14)			V1 - V2		
6006	0.1	-1.1	0.4	6006	-2.9	33.2	-12.0	2.9	-34.3	12.4
6015	0.1	0.0	0.1	6015	-12.4	-4.3	-14.6	12.4	4.3	14.7
6016	0.3	-1.2	-0.0	6016	-13.1	35.0	1.1	13.4	-36.2	-1.1
6065	0.2	-1.1	-0.2	6065	-3.3	14.1	3.1	3.5	-15.3	-3.3
8009	-2.7	0.1	0.6	8009	9.5	-0.2	-3.3	-12.2	0.3	3.9
8010	-1.3	1.6	1.0	8010	10.1	-5.8	-8.7	-11.4	7.3	9.7
8011	-0.5	10.0	0.2	8011	3.9	-30.7	-2.1	-4.3	40.6	2.2
8015	-0.2	5.4	0.0	8015	1.4	-12.1	-0.1	-1.6	17.4	0.1
8019	-0.0	1.8	-0.0	8019	0.9	-17.6	0.7	-1.0	19.3	-0.7
8030	-1.7	7.7	0.7	8030	5.8	-11.9	-2.9	-7.4	19.5	3.6
9004	0.1	1.9	0.0	9004	-7.3	-19.8	-3.0	7.4	21.7	3.1
9006	-1.5	0.4	-0.2	9006	6.0	-8.4	3.9	-7.5	8.8	-4.1
9008	-0.5	0.9	0.7	9008	7.5	-15.7	-12.5	-8.1	16.6	13.3
9091	-0.2	5.7	-0.3	9091	5.9	-23.6	6.9	-6.1	29.3	-7.2
9426	0.4	1.6	-0.3	9426	-2.6	-8.2	4.4	3.1	9.9	-4.7
9431	-0.5	14.0	-3.6	9431	1.4	-70.5	32.4	-1.9	84.5	-36.0

UNIT OF RESIDUALS (METERS)

Table 2.2-3

NAD-27 to WN-14 (Veis Model)

DU METERS	DV METERS	DW METERS	DELTA (X1.D+6)	ALPHA SECONDS	KSI SECONDS	ETA SECONDS
-31.71	142.34	177.32	-0.80	-0.33	-0.29	0.84
± 1.35	± 1.26	± 1.23	± 0.27	± 0.05	± 0.10	± 0.06

VARIANCE - COVARIANCE MATRIX

SO2= 0.76

0.182D+01	-0.258D-02	-0.280D-02	-0.724D-07	0.189D-07	0.113D-07	0.871D-08
-0.258D-02	0.159D+01	0.154D-02	0.103D-07	0.320D-07	0.851D-07	-0.544D-07
-0.280D-02	0.154D-02	0.151D+01	0.207D-07	0.370D-07	0.214D-07	0.400D-07
-0.724D-07	0.103D-07	0.207D-07	0.734D-13	-0.171D-15	0.256D-15	0.118D-15
0.189D-07	0.320D-07	0.370D-07	-0.171D-15	0.618D-13	-0.504D-14	-0.448D-14
0.113D-07	0.851D-07	0.214D-07	0.256D-15	-0.504D-14	0.247D-12	0.105D-13
0.871D-08	-0.544D-07	0.400D-07	0.118D-15	-0.448D-14	0.105D-13	0.800D-13

COEFFICIENTS OF CORRELATION

0.100D+01	-0.151D-02	-0.169D-02	-0.198D+00	0.563D-01	0.169D-01	0.228D-01
-0.151D-02	0.100D+01	0.992D-03	0.302D-01	0.102D+00	0.136D+00	-0.152D+00
-0.169D-02	0.992D-03	0.100D+01	0.621D-01	0.121D+00	0.350D-01	0.115D+00
-0.198D+00	0.302D-01	0.621D-01	0.100D+01	-0.254D-02	0.190D-02	0.154D-02
0.563D-01	0.102D+00	0.121D+00	-0.254D-02	0.100D+01	-0.408D-01	-0.637D-01
0.169D-01	0.136D+00	0.350D-01	0.190D-02	-0.408D-01	0.100D+01	0.748D-01
0.228D-01	-0.152D+00	0.115D+00	0.154D-02	-0.637D-01	0.748D-01	0.100D+01

NOTE : THE POSITIVE ROTATIONS ARE TOWARDS SOUTH

EAST , AND ALONG ELLIPSOIDAL NORMAL UPWARDS.

Note: Scale factor and rotation parameters constrained.

Table 2.2-3 (Continued)

RESIDUALS V

	V1(NAD-27)				V2(WN- 14)			V1 - V2		
1021	1.0	0.2	1.3	1021	-3.9	-0.9	-3.8	4.8	1.1	5.1
1022	0.0	0.5	0.5	1022	-0.1	-3.0	-2.3	0.2	3.5	2.8
1030	-0.5	-0.3	1.4	1030	2.7	0.9	-6.2	-3.2	-1.2	7.6
1034	-2.9	1.8	1.2	1034	5.4	-5.4	-3.9	-8.3	7.1	5.0
1042	2.5	0.2	1.1	1042	-7.6	-0.8	-3.1	10.1	1.0	4.1
3400	0.5	0.6	2.2	3400	-1.5	-3.2	-5.1	2.0	3.8	7.4
3401	2.2	-0.8	-1.1	3401	-9.1	3.1	3.1	11.3	-3.9	-4.2
3402	0.2	-0.7	0.7	3402	-0.3	2.4	-1.6	0.5	-3.1	2.3
3648	-1.1	0.2	1.5	3648	2.5	-0.8	-2.7	-3.6	1.0	4.2
3657	2.5	0.6	-0.4	3657	-8.8	-2.4	1.0	11.3	3.1	-1.4
3861	-1.5	-0.8	-0.2	3861	4.7	3.4	0.6	-6.2	-4.1	-0.8
4280	0.9	-1.0	-0.9	4280	-4.4	5.1	4.1	5.3	-6.1	-5.1
6002	0.1	-0.6	-0.9	6002	-0.5	5.8	6.5	0.5	-6.3	-7.4
6003	0.0	-0.5	-0.9	6003	-0.5	17.5	6.9	0.6	-18.1	-7.7
6134	0.5	-0.4	-0.6	6134	-5.5	4.5	5.2	6.0	-4.9	-5.8
7036	-2.2	2.2	0.2	7036	4.5	-9.6	-0.7	-6.7	11.7	0.9
7043	0.1	-0.6	-0.9	7043	-0.5	5.8	6.4	0.5	-6.4	-7.3
7045	-3.6	0.5	-0.6	7045	7.5	-1.9	2.0	-11.1	2.5	-2.6
7072	0.4	0.2	0.4	7072	-4.1	-2.5	-4.7	4.5	2.7	5.1
7075	-2.7	-0.8	-0.1	7075	6.3	2.3	0.2	-9.0	-3.1	-0.3
9001	-0.4	0.4	0.6	9001	5.2	-6.8	-6.2	-5.6	7.1	6.8

UNIT OF RESIDUALS (METERS)

Table 2.2-4

SAD-69 to WN-14 (Veis Model

DU METERS	DV METERS	DW METERS	DELTA (X1.D+6)	ALPHA SECONDS	KSI SECONDS	ETA SECONDS
-96.57	-13.67	-29.36	-6.67	-0.02	-0.03	-0.66
± 3.02	± 3.02	± 3.15	± 0.59	± 0.11	± 0.13	± 0.17

VARIANCE - COVARIANCE MATRIX

SO2= 0.97

0.915D+01	-0.172D+00	-0.202D+00	0.419D-06	-0.271D-06	0.244D-06	-0.248D-06
-0.172D+00	0.912D+01	0.697D-01	0.231D-06	-0.378D-07	-0.266D-06	0.831D-06
-0.202D+00	0.697D-01	0.989D+01	-0.410D-06	-0.317D-06	0.928D-07	0.244D-06
0.419D-06	0.231D-06	-0.410D-06	0.352D-12	0.436D-16	0.294D-14	-0.137D-14
-0.271D-06	-0.378D-07	-0.317D-06	0.436D-16	0.287D-12	0.319D-13	0.529D-13
0.244D-06	-0.266D-06	0.928D-07	0.294D-14	0.319D-13	0.417D-12	0.583D-13
-0.248D-06	0.831D-06	0.244D-06	-0.137D-14	0.529D-13	0.583D-13	0.667D-12

COEFFICIENTS OF CORRELATION

0.100D+01	-0.188D-01	-0.212D-01	0.234D+00	-0.167D+00	0.125D+00	-0.101D+00
-0.188D-01	0.100D+01	0.734D-02	0.129D+00	-0.234D-01	-0.136D+00	0.337D+00
-0.212D-01	0.734D-02	0.100D+01	-0.219D+00	-0.188D+00	0.457D-01	0.950D-01
0.234D+00	0.129D+00	-0.219D+00	0.100D+01	0.137D-03	0.767D-02	-0.283D-02
-0.167D+00	-0.234D-01	-0.188D+00	0.137D-03	0.100D+01	0.923D-01	0.121D+00
0.125D+00	-0.136D+00	0.457D-01	0.767D-02	0.923D-01	0.100D+01	0.111D+00
-0.101D+00	0.337D+00	0.950D-01	-0.283D-02	0.121D+00	0.111D+00	0.100D+01

NOTE : THE POSITIVE ROTATIONS ARE TOWARDS SOUTH

EAST , AND ALONG ELLIPSOIDAL NORMAL UPWARDS.

Note: Scale factor and rotation parameters constained.

Table 2.2-4 (Continued)

RESIDUALS V

	V1(SAD-69)				V2(WN- 14)			V1 - V2		
3414	4.1	-1.3	6.3	3414	-1.8	0.8	-3.0	5.9	-2.1	9.2
3431	-1.0	2.5	0.1	3431	1.1	-3.7	-0.1	-2.0	6.2	0.2
3477	16.3	2.3	13.9	3477	-10.1	-3.4	-9.8	26.3	5.8	23.7
6008	0.0	0.3	2.0	6008	-0.3	-5.1	-14.6	0.4	5.4	16.6
6009	-2.0	-1.0	-1.9	6009	9.9	5.4	7.1	-11.9	-6.4	-9.0
6019	-0.1	-0.2	-0.8	6019	1.5	2.1	3.8	-1.6	-2.3	-4.6
6067	-0.2	-0.5	-0.8	6067	2.8	7.4	7.5	-3.0	-7.9	-8.3
9007	1.0	0.4	-1.2	9007	-10.7	-2.9	3.9	11.8	3.3	-5.1
9009	-0.5	0.0	-1.9	9009	5.8	-0.6	10.8	-6.3	0.6	-12.8
9031	-5.0	1.6	2.2	9031	4.6	-1.3	-1.1	-9.6	2.9	3.3

UNIT OF RESIDUALS (METERS)

(d) To avoid the singularity in the solution and add necessary strength, the model needs at least three datums well distributed over the globe with minimum of three stations on each datum.

The model is as under (a correction sheet to the original paper is given in Attachment 1):

$$Q(\omega,\psi,\epsilon)\,\vec{\rho}_i - Q(\Delta)\,\vec{r}_i - \Delta L(\vec{r}_0 + \vec{r}_i) - \vec{r}_{SG} = \vec{d}_i \tag{3}$$

where

$$Q(\omega,\psi,\epsilon) = \begin{bmatrix} 0 & \epsilon & -\psi \\ -\epsilon & 0 & \omega \\ \psi & -\omega & 0 \end{bmatrix}$$

$$Q(\Delta) = \Delta \begin{bmatrix} 0 & \sin\varphi_0 & -\cos\varphi_0 \sin\lambda_0 \\ -\sin\varphi_0 & 0 & \cos\varphi_0 \cos\lambda_0 \\ \cos\varphi_0 \sin\lambda_0 & -\cos\varphi_0 \cos\lambda_0 & \end{bmatrix}$$

(φ_0, λ_0) ≡ Coordinates of the initial point.

ΔL ≡ Scale factor for the datum.

$\bar{\rho}_i \; : \; \begin{bmatrix} x \\ y \\ z \end{bmatrix}_i$ ≡ Position vector for point i in the satellite system.

$\bar{r}_i = \begin{bmatrix} u \\ v \\ w \end{bmatrix}_i$ ≡ Position vector for the corresponding point i on the geodetic datum.

$\bar{r}_0 \; \begin{bmatrix} \Delta u \\ \Delta v \\ \Delta w \end{bmatrix}_0$ ≡ Position vector for the initial point on the geodetic datum.

$\overline{r}_{SG}$ or $\begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix}$ $\equiv$ Position vector of datum origin defining three translation parameter.

$$\overline{d}_i \equiv \vec{r}_0 + \vec{r}_i - \overline{\rho}_i$$

> <u>Note</u>: Thus the unknowns to be considered are three parameters (ω, ψ, ϵ) for the satellite system and five parameters (r_{SG} , Δ, ΔL) for each geodetic datum considered, i.e., a minimum of eighteen parameters with three datums.

If P_{ij} denotes a point "i" falling on datum "j", then extending the above equation (3) to include more than one datum (j = 1, 2, 3), we can further modify as under:

$$BV + AX + W = 0 \tag{4}$$

where

$$B \equiv \begin{array}{c l}
\begin{array}{cccccccccccc} & & & & j = 1 & & & j = 2 & & & j = 3 & \end{array} & \\
\left[\begin{array}{ccc|ccc|ccc|ccc}
1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & -1 & 0 & 0 & & & & & & \\
0 & 1 & 0 & 0 & -1 & 0 & & 0 & & & 0 & \\
0 & 0 & 1 & 0 & 0 & -1 & & & & & & \\
 & I & & & -I & & & 0 & & & 0 & \\
 & - & & & - & & & - & & & - & \\
\hline
 & I & & & 0 & & & -I & & & 0 & \\
 & - & & & - & & & - & & & - & \\
 & - & & & - & & & - & & & - & \\
\hline
 & I & & & 0 & & & 0 & & & -I & \\
 & - & & & - & & & - & & & - & \\
 & I & & & 0 & & & 0 & & & -I &
\end{array}\right] &
\begin{array}{l}
\text{1st datum} \\ \text{with k point} \\ \\ i \\
\text{2nd datum} \\ \text{with } \ell \text{ points} \\ i = k + \ell \\
\text{3rd datum} \\ \text{with m points} \\ i = (k + \ell + m)
\end{array}
\end{array}$$

$$V^T \equiv [V_{x_i}\ V_{y_i}\ V_{z_i}, V_{u_{i1}}\ V_{v_{i1}}\ V_{w_{i1}}\ V_{u_{i2}}\ V_{v_{i2}}\ V_{w_{i2}}, V_{u_{i3}}\ V_{v_{i3}}\ V_{w_{i3}}]$$

$$X^T \equiv [\omega, \psi, \epsilon, \Delta_1, \Delta x_1\ \Delta y_1\ \Delta z_1\ \Delta L_1, \Delta_2, \Delta x_2\ \Delta y_2\ \Delta z_2\ \Delta L_2, \Delta_3\ \Delta x_3\ \Delta y_3\ \Delta z_3\ \Delta L_3]$$

$$A \equiv \begin{array}{c c l}
 & \begin{array}{cccc} & j=1 & j=2 & j=3 \end{array} & \\
 & \left[\begin{array}{c|c|c|c} R_i & S_{ij} & 0 & 0 \\ \hline R_i & 0 & S_{ij} & 0 \\ \hline R_i & 0 & 0 & S_{ij} \end{array}\right] & \begin{array}{l} \text{1st datum - with k points} \quad i = k \\ \text{2nd datum - with } \ell \text{ points} \quad i = k + \ell \\ \text{3rd datum - with m points} \quad i = k + \ell + m \end{array}
\end{array}$$

with $R_i \equiv \begin{bmatrix} -y & z & 0 \\ x & 0 & -z \\ 0 & -x & y \end{bmatrix}_i$

$$S_{ij} \equiv \begin{bmatrix} -\sin\varphi_{0j}(V_i - \Delta V_j) + \cos\varphi_{0j}\sin\lambda_{0j}(w_i - \Delta w_j) & -1 & 0 & 0 & -U_i \\ \sin\varphi_{0j}(u_i - \Delta u_j) - \cos\varphi_{0j}\cos\lambda_{0j}(w_i - \Delta w_j) & 0 & -1 & 0 & -V_i \\ -\cos\varphi_{0j}\sin\lambda_{0j}(u_i - \Delta u_j) + \cos\varphi_{0j}\cos\lambda_{0j}(v_i - \Delta v_j) & 0 & 0 & -1 & -W_i \end{bmatrix}$$

$$W_{ij} \equiv \begin{bmatrix} U - X \\ V - Y \\ W - Z \end{bmatrix}_{ij}$$

A test solution was run with four major datums viz Australian (3 points), South American (10 points), European 1950 (16 points) and North American (21 points) with corresponding 50 points from WN-14 system. The results are given in Table 2.2-6.

Table 2.2-6

Transformations of four datums and the WN-14 System to the Average Terrestrial System (Vanicek Model)

OMEGA SECONDS	PSI SECONDS	EPSILON SECONDS	DELTA SECONDS	DU METERS	DV METERS	DW METERS	SCALE (X 1.D6)	
0.40 ± 0.26	0.86 ± 0.33	-0.15 ± 0.28	0.15 ± 0.51	-131.75 ± 8.11	-54.21 ± 8.78	121.32 ± 8.07	1.10 ± 1.57	AUS.NAT.
			-0.76 ± 0.43	-72.57 ± 9.83	-43.55 ± 8.70	-29.61 ± 7.52	-6.77 ± 1.35	SAD 1969
			0.82 ± 0.63	-140.25 ±14.36	-147.90 ± 9.34	-129.55 ±15.04	6.06 ± 2.73	ED 1950
			-0.75 ± 0.42	-56.49 ± 6.01	137.35 ± 7.65	174.55 ± 8.35	-0.93 ± 1.10	NAD 1927

VARIANCE-COVARIANCE/CORRELATION MATRIX

SO2= 1.04

0.16098D-11	-0.11730D-11	0.23195D-12	-0.16248D-11	0.31736D-05	[illegible]
0.54361D-05	-0.25670D-14	0.61260D-12	-0.10114D-04	[illegible]	[illegible]
-0.11551D-14	[illegible]	0.67914D-05	[illegible]	[illegible]	0.74410D-14
0.18717D-11	[illegible]	0.15215D-05	0.21327D-05	[illegible]	
[illegible]	0.26373D-11	-0.87150D-12	0.37413D-11	[illegible]	[illegible]
[illegible]	[illegible]	-0.22464D-11	0.11092D-04	[illegible]	[illegible]
[illegible]	[illegible]	-0.13155D-04	[illegible]	[illegible]	-0.19717D-14
-0.27783D-11	[illegible]	[illegible]	[illegible]	0.25517D-13	
[illegible]	[illegible]	[illegible]	-0.17999D-11	[illegible]	-0.42344D-05
-0.40442D-05	0.11372D-12	0.17093D-11	[illegible]	[illegible]	0.48850D-05
[illegible]	0.85569D-12	0.41020D-05	0.79990D-05	[illegible]	-0.10373D-13
[illegible]	0.23655D-05	[illegible]	0.95744D-05	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	-0.27571D-11	[illegible]	[illegible]	[illegible]
0.16729D-12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Table 2.2-6 (Continued - 2)

VARIANCE-COVARIANCE/CORRELATION MATRIX

SO2= 1.04

0.30835D+00	0.17899D+00	-0.12224D+00	0.18065D-01	0.65845D+02	-0.22258D+02
0.21769D+02	0.10034D-04	-0.34454D-05	-0.10260D+02	-0.66560D+01	0.39863D+01
-0.47763D-07	0.25723D-05	-0.81094D+01	-0.17746D+02	0.10820D+02	0.23009D-07
0.11279D-06	-0.24542D+02	-0.48197D+01	-0.66667D+01	0.81254D-07	

0.50788D+00	-0.14948D+00	-0.35438D+00	-0.22653D-01	-0.31231D+00	0.77141D+02
-0.17251D+00	-0.95421D-05	-0.23223D-05	-0.29399D+02	-0.10445D+02	-0.24954D+02
0.99818D-07	0.13044D-05	0.14969D+02	-0.41358D+02	-0.44355D+01	0.57160D-07
0.54617D-05	-0.18717D+02	-0.12873D+02	-0.17943D+02	0.88772D-07	

0.33551D+00	-0.48930D+00	-0.26818D+00	-0.13085D+00	0.33226D+00	-0.24326D-02
0.65194D+02	0.61976D-05	0.16797D-05	-0.26833D+02	-0.49136D+01	-0.41042D+02
0.20995D-06	-0.18569D-05	0.32870D+02	-0.32950D+02	-0.21872D+02	0.47724D-07
0.75677D-05	0.88651D+01	-0.11259D+02	-0.15768D+02	0.85358D-08	

-0.12987D-02	0.13449D-01	0.53210D-02	-0.22310D-01	0.78720D+00	-0.69160D+00
0.48862D+00	0.24677D-11	-0.19141D-13	0.71964D-07	-0.43207D-08	0.17925D-05
-0.10132D-14	0.16563D-13	-0.16162D-06	0.69171D-07	0.12701D-06	-0.10985D-15
-0.30153D-13	-0.12313D-06	0.27756D-07	0.39171D-07	0.25632D-15	

0.23147D+00	-0.66268D+00	0.60197D+00	-0.53543D+00	-0.20341D+00	-0.12667D+00
0.99661D-01	-0.58372D-02	0.43572D-11	-0.97344D-05	-0.48795D-05	-0.29833D-05
-0.13347D-13	0.62956D-12	0.10814D-04	0.56402D-05	-0.10651D-04	-0.65296D-14
0.20030D-11	0.58596D-05	0.69309D-05	0.96495D-05	-0.36492D-13	

-0.81119D+00	0.69485D+00	-0.26663D+00	0.57415D+00	-0.12863D+00	-0.34052D+00
-0.33808D+00	0.46604D-02	-0.47442D+00	0.96625D+02	0.88682D+01	0.20335D+02
-0.51575D-05	-0.59356D-05	-0.59767D+02	0.21504D+02	0.47822D+02	-0.34778D-07
-0.14548D-04	0.50565D+01	-0.18699D+02	-0.26044D+02	0.41834D-07	

Table 2.2-6 (Continued - 3)

VARIANCE-COVARIANCE/CORRELATION MATRIX

SO2= 1.04

-0.45201D+00	0.34237D+00	-0.27500D+00	0.34513D+00	-0.97078D-01	-0.13664D+00
-0.69921D-01	-0.31602D-03	-0.26959D+00	0.10366D+00	0.75750D+02	0.12350D+02
0.94389D-05	-0.39885D-05	-0.26463D+02	0.33232D+01	0.22474D+02	-0.70121D-08
-0.65260D-05	0.50365D+01	-0.14283D+02	-0.19916D+02	0.28535D-07	
-0.31772D+00	0.47644D+00	0.47768D+00	0.10756D+00	0.65342D-01	-0.37790D+00
-0.67609D+00	0.15176D-01	-0.19009D+00	0.27516D+00	0.18873D+00	0.55526D+02
0.15618D-05	0.24296D-05	-0.29801D+02	0.35418D+02	0.10666D+02	-0.50757D-07
-0.69265D-05	-0.84815D+01	0.14523D+02	0.20319D+02	-0.19212D-07	
-0.10838D-02	-0.64533D-02	-0.21455D-01	0.30171D-02	-0.43548D-02	0.94062D-02
0.19238D-01	-0.47719D-03	-0.47306D-02	-0.38817D+00	0.80236D+00	0.15369D+00
0.18270D-11	-0.28497D-13	0.66320D-07	-0.18406D-06	-0.19308D-07	0.25644D-15
0.14026D-13	0.65861D-07	-0.13459D-06	-0.18805D-06	0.21510D-15	
0.24774D+00	-0.93339D-01	0.21372D+00	-0.17125D+00	0.10406D+00	0.48754D-01
-0.75498D-01	0.34612D-02	0.99010D-01	-0.19872D+00	-0.15645D+00	0.10698D+00
-0.64199D-02	0.92794D-11	0.22376D-05	0.42216D-05	-0.15120D-05	-0.15201D-12
0.65266D-12	-0.28122D-05	0.35004D-05	0.48863D-05	-0.26445D-14	
0.37367D+00	-0.56402D+00	0.20996D+00	-0.39432D+00	-0.64591D-01	0.11868D+00
0.28348D+00	-0.71644D-02	0.36075D+00	-0.42339D+00	-0.21173D+00	-0.27601D+00
0.34167D-02	[illegible]	[illegible]	[illegible]	0.80817D+02	-0.30025D-04
0.14189D-04	0.19032D+02	0.20519D+02	0.28526D+02	-0.11307D-06	
[illegible]	[illegible]	0.61949D+00	-0.99776D-01	[illegible]	-0.50797D+00
-0.43675D+00	0.47127D-02	0.28919D+00	0.23413D+00	[illegible]	0.50419D+00
[illegible]	[illegible]	0.18364D+00	0.17303D+02	0.31219D+02	-0.61076D-05
-0.41393D-05	[illegible]	0.26802D+02	[illegible]	-0.11903D-06	

Table 2.2-6 (Continued - 4)

VARIANCE-COVARIANCE/CORRELATION MATRIX

SO2= 1.04

-0.25647D+00	0.46722D+00	-0.25735D+00	0.34261D+00	0.88648D-01	-0.33574D-01
-0.18008D+00	0.53749D-02	-0.33921D+00	0.32343D+00	0.17166D+00	0.16506D+00
-0.94968D-03	-0.34527D-01	0.37413D+00	0.22213D+00	0.22626D+03	-0.34242D-04
-0.11555D-04	-0.21296D+02	-0.23584D+02	-0.32811D+02	0.12810D-06	

0.21452D-02	-0.44396D-03	-0.27881D-02	0.25706D-03	0.10369D-02	0.23797D-02
0.21613D-02	-0.25569D-04	-0.11438D-02	-0.12937D-02	-0.29460D-03	-0.24686D-02
0.69375D-04	-0.18247D-01	-0.76452D+00	-0.31729D+00	-0.83242D+00	0.74789D-11
0.69722D-14	-0.27766D-07	-0.34129D-07	-0.47606D-07	0.17598D-15	

0.72323D+00	-0.62252D+00	0.23351D+00	-0.59362D+00	0.68052D-02	0.30445D+00
0.45887D+00	-0.95975D-02	0.46981D+00	-0.72458D+00	-0.36710D+00	-0.45105D+00
0.50803D-02	0.13704D+00	0.48370D+00	-0.21689D+00	-0.37609D+00	0.12482D-02
0.41719D-11	0.20212D-05	0.39731D-05	0.57888D-05	-0.44634D-13	

-0.40955D+00	-0.48370D+00	0.28910D+00	-0.19814D+00	-0.50290D+00	-0.35435D+00
0.18257D+00	-0.13033D-01	0.46677D+00	0.85534D-01	0.96271D-01	-0.18758D+00
0.81046D-02	-0.15351D+00	0.22038D+00	0.39322D+00	-0.23542D+00	-0.16882D-02
0.16454D+00	0.36168D+02	0.78028D+01	0.14126D+02	-0.42982D-06	

0.15674D+00	-0.24142D+00	0.65953D+00	-0.40544D+00	-0.77612D-01	-0.19151D+00
-0.18271D+00	0.23087D-02	0.45387D+00	-0.24856D+00	-0.21443D+00	0.25240D+00
-0.13011D-01	0.15015D+00	0.18670D+00	0.37481D+00	-0.20487D+00	-0.16311D-02
0.25417D+00	0.16953D+00	0.58569D+02	0.13953D+02	0.59281D-05	

0.20041D+00	-0.43459D+00	0.84276D+00	-0.51756D+00	-0.98283D-01	-0.24464D+00
-0.23386D+00	0.29860D-02	0.55357D+00	-0.31728D+00	-0.27402D+00	0.32364D+00
-0.16660D-01	0.19216D+00	0.23767D+00	0.47892D+00	-0.26121D+00	-0.20846D-02
0.33938D+00	0.28128D+00	0.21832D+00	0.69735D+02	-0.46378D-05	

Table 2.2-6 (Continued - 5)

VARIANCE-COVARIANCE/CORRELATION MATRIX

SD2= 1.04

0.28627D-02	0.14336D-01	-0.17900D-01	0.11349D-01	0.91365D-02	0.92220D-02
0.96458D-03	0.14887D-05	-0.15951D-01	0.38831D-02	0.29915D-02	-0.23315D-02
0.14520D-03	-0.79269D-05	-0.71807D-02	-0.13577D-01	0.77704D-02	0.58713D-04
-0.19938D-01	-0.65211D-01	0.70677D+00	-0.50674D+00	0.12012D-11	

Table 2.2-6 (Continued - 6)

RESIDUALS V

V1(4-DATUMS)				V2(WN - 14)				V1 - V2		
6023	0.2	0.1	-3.6	6023	-0.2	-0.2	2.3	0.3	0.3	-5.9
6032	2.8	-0.7	2.5	6032	-2.6	0.7	-1.6	5.5	-1.5	4.1
6060	-3.0	0.6	0.9	6060	2.8	-0.6	-0.7	-5.8	1.2	1.5
3414	2.2	2.5	6.5	3414	-0.9	-1.6	-3.1	3.1	4.1	9.6
3431	-2.0	4.3	0.5	3431	2.3	-6.4	-0.3	-4.3	10.7	0.7
3477	19.4	-0.7	13.1	3477	-12.0	1.0	-9.2	31.4	-1.7	22.2
6008	0.1	0.3	1.9	6008	-1.8	-4.4	-13.8	1.9	4.7	15.7
6009	-1.1	-2.2	-2.1	6009	5.6	12.2	8.1	-6.7	-14.4	-10.3
6019	-0.3	0.1	-0.6	6019	3.8	-0.5	2.8	-4.1	0.6	-3.4
6067	-0.5	-0.0	-0.7	6067	7.9	0.1	6.3	-8.4	-0.1	-7.0
9007	1.2	0.2	-1.3	9007	-12.6	-1.4	4.4	13.8	1.5	-5.7
9009	-0.1	-0.4	-2.1	9009	1.6	6.3	11.9	-1.7	-6.7	-14.0
9031	-8.3	3.3	4.5	9031	7.7	-2.8	-2.3	-16.0	6.1	6.8
6006	0.2	-1.1	0.5	6006	-8.2	32.5	-16.7	8.4	-33.6	17.2
6015	0.0	0.0	0.1	6015	-9.9	-0.9	-16.6	10.0	0.9	16.7
6016	0.2	-1.2	-0.1	6016	-10.4	35.4	3.4	10.6	-36.6	-3.5
6065	0.2	-1.1	-0.3	6065	-3.6	12.8	3.6	3.8	-14.9	-3.9
8009	-2.3	0.3	0.7	8009	8.3	-0.8	-3.6	-10.6	1.2	4.3
8010	-1.3	1.7	0.9	8010	10.0	-6.2	-8.1	-11.3	7.8	9.0
8011	-0.3	10.3	0.2	8011	2.3	-31.5	-2.8	-2.6	41.9	3.0
8015	-0.3	5.5	-0.1	8015	2.1	-12.4	1.0	-2.3	17.9	-1.1
8019	-0.0	1.8	-0.1	8019	1.7	-17.9	1.9	-1.8	19.7	-2.0
8030	-1.5	8.0	0.7	8030	5.2	-12.4	-2.9	-6.7	20.4	3.5
9004	0.1	2.0	0.0	9004	-4.7	-20.6	-1.5	4.7	22.6	1.5
9006	-2.2	0.2	0.1	9006	8.9	-3.6	-2.2	-11.1	3.8	2.3
9008	-0.9	0.7	0.8	9008	12.0	-17.3	-12.8	-12.9	18.1	13.5
9091	-0.3	5.5	-0.4	9091	8.4	-22.8	8.9	-8.6	28.3	-9.3
9426	1.0	1.8	-0.2	9426	-5.6	-8.9	7.3	6.6	10.7	-7.5
9431	0.2	14.0	-3.5	9431	-0.6	-70.6	31.0	0.8	84.6	-34.4
1021	0.9	0.4	1.2	1021	-3.8	-1.7	-3.5	4.8	2.1	4.7
1022	-0.0	0.2	0.8	1022	0.1	-1.2	-3.8	-0.1	1.5	4.6
1030	-0.5	-0.3	1.4	1030	2.5	1.0	-6.1	-2.9	-1.3	7.5
1034	-2.8	2.5	0.7	1034	5.2	-7.5	-2.4	-8.0	10.0	3.2
1042	2.5	0.3	1.2	1042	-7.5	-0.9	-3.4	10.0	1.2	4.7
3400	0.5	0.7	2.2	3400	-1.7	-3.9	-5.1	2.2	4.6	7.3
3401	2.2	-0.4	-1.5	3401	-9.0	1.6	4.4	11.2	-2.0	-6.0
3402	0.2	-1.0	1.1	3402	-0.3	3.1	-2.7	0.4	-4.1	3.8
3648	-1.1	0.1	1.8	3648	2.6	-0.3	-3.3	-3.8	0.4	5.1
3657	2.5	0.9	-0.6	3657	-8.8	-3.4	1.6	11.2	4.3	-2.1
3861	-1.6	-1.2	0.3	3861	5.0	5.2	-0.9	-6.5	-6.4	1.2
4280	1.0	-1.1	-1.0	4280	-4.7	5.4	4.4	5.6	-6.4	-5.4
6002	0.1	-1.5	-1.0	6002	-0.4	4.8	7.1	0.5	-6.2	-8.1
6003	0.0	-0.5	-1.2	6003	-1.0	15.1	9.2	1.0	-15.6	-10.4
6134	0.8	-0.4	-1.5	6134	-5.5	4.8	5.3	6.3	-5.2	-6.8
7036	-2.3	1.7	0.7	7036	4.5	-7.8	-2.5	-6.8	9.5	3.2

Table 2.2-6 (Continued - 7)

RESIDUALS V

V1(4-DATUMS)				V2(WN - 14)				V1 - V2		
7043	0.1	-0.5	-1.0	7043	-0.4	4.8	7.0	0.5	-5.3	-7.9
7045	-3.5	0.8	-0.7	7045	7.3	-2.7	2.1	-10.8	3.5	-2.8
7072	0.3	0.1	0.6	7072	-3.9	-0.7	-6.2	4.2	0.8	6.8
7075	-2.7	-0.1	-0.6	7075	6.2	0.4	1.6	-8.8	-0.5	-2.2
9001	-0.3	0.3	0.7	9001	5.1	-6.1	-7.2	-5.4	6.4	8.0

UNIT OF RESIDUALS (METERS)

Mr. Alfred Leick
Department of Geodetic Science
The Ohio State University
1958 Neil Avenue
Columbus, Ohio 43210
U.S.A.

Dear Mr. Leick:

Thank you for your letter of August 2. We were delighted to hear that you are interested in using our method to investigate geodetic net distortions. Thank you for drawing our attention to the errors which you have found in the equations. Unfortunately, you are correct in all cases. We obtained an additional error in equation 18. The attached sheet summarizes changes which should be made to equations, 16, 17, 18, 25, 25a, 25b, and 28.

Please keep us informed of the progress you make using this method. We in turn will send you any further thoughts which we have.

Yours truly,

Petr Vaníček

D. E. Wells

PV/DEW/ga

Encl.

Corrections to Equations in "Positioning of Geodetic Datums"

By P. Vanicek and D. E. Wells

(16) use $R(-\eta_o, -\xi_o, -\zeta_o)$

(17) use
$$\begin{bmatrix} 0 & -\zeta_o & \xi_o \\ \zeta_o & 0 & -\eta_o \\ -\xi_o & \eta_o & 0 \end{bmatrix}$$

(18) use
$$\begin{bmatrix} 0 & -\zeta_o & \xi_o \\ \zeta_o & 0 & -\eta_o \\ -\xi_o & \eta_o & 0 \end{bmatrix} \begin{bmatrix} \cos A \ \sin B \\ \sin A \ \sin B \\ \cos B \end{bmatrix}$$

(25) introduced by "(expressing all vectors in the Average Terrestrial system)"

(25a) is
$$R(\omega,\psi,\varepsilon) = \begin{bmatrix} 1 & \varepsilon & -\psi \\ -\varepsilon & 1 & \omega \\ \psi & -\omega & 1 \end{bmatrix}$$

(25b) is
$$R(\Delta) = R(\omega_G,\psi_G,\varepsilon_G) = \begin{bmatrix} 1 & \varepsilon_G & -\psi_G \\ -\varepsilon_G & 1 & \omega_G \\ \psi_G & -\omega_G & 1 \end{bmatrix}$$

after eqn. (26) list is "$\omega,\psi,\varepsilon,\Delta,\vec{r}_{SG}$, ΔL".

(28) is
$$Q(\Delta) = \Delta \left[\begin{array}{c|c|c} 0 & \sin\phi_o & -\cos\phi_o \sin\lambda_o \\ -\sin\phi_o & 0 & \cos\phi_o \cos\lambda_o \\ \cos\phi_o \ \sin\lambda_o & -\cos\phi_o \ \cos\lambda_o & 0 \end{array}\right]$$

2.3 Determination of Network Distortions

During the past months further investigations as to the determination of distortions in major geodetic networks have been made. The procedure used is described in the Fourteenth Semiannual Status Report on pages 50 and 51. The principle of this procedure is to look for the systematic residuals of station coordinates after the transformations between the satellite system and the geodetic datum were performed.

Detailed investigations were done for the South American (SAD69) and the European geodetic Datums using the OSU 275 satellite system as reference. No systematic pattern for the residuals $V_{SAT} - V_{GEOD}$ could be seen in either case. Three, four and seven parameter transformations were computed using both the Molodensky and Veis models. The Vanicek model, which is detailed in section 2.22, was not used since its requirements concerning the distribution of stations is not fulfilled for the available stations.

2.31 Determination of Network Distortions for NAD-27

Despite the work which was done in regard to deformations for the North American Datum, which was presented in the Fourteenth Semiannual Status Report, it was felt that the procedure should be tested again using the more homogeneous NWL-9D Doppler system as comparison standard. Mr. Meade of the National Ocean Survey, Rockville, Maryland, supplied the coordinates of 88 Geoceiver stations and the corresponding geodetic coordinates for the NAD. Additional coordinates for Doppler stations in South America and Europe are expected to be at our disposal shortly. See also the correspondence in Attachments 1 and 2.

The NOS data was given in the form of geodetic coordinates φ, λ, h. In each case the antenna height was given and had to be reduced to the marks. Although the transformation program permits geodetic or

Cartesian coordinates as input data, geodetic coordinates were computed for later convenience using the NWL-9D ellipsoid:

$$a = 6378145 \text{ m}$$

$$f = 1/298.25$$

A summary of coordinates is given in Tables 2.3-1 through 2.3-4.

Before the coordinates were used in the transformations, double stations and nearby stations, etc. were eliminated. Some comments to particular stations can be found in a paper by K. Meade, "Geoceiver Positions Compared with Results of Precise Surveys," which was presented at the meeting of the International Federation of Surveyors (FIG), Washington D.C., September 7-16, 1974. A summary is given here:

10028	EGLIN AFB, FL	NAD position not verified
10033	BUCKLEY, CO	NAD position not verified
30029	MOSES LAKE, WASH	Two re-observations available; same station numbers; all observations can be considered equivalent
51063	DOS PALOS, CA	Height is in error by about 5 m
52063, 53063		Re-observations for station 51063
20001 52001 52002 60001	BELTSVILLE, MD	Identical or nearby stations
51068	YULEE, FLA	Substitute station for station 20015
20003	WRIGHTWOOD, CA	Eccentric station with 51070
T008	AZ	The name of this station could not be identified from the data sheet. In order not to change the available programs the station was renumbered to 9008.

Most of the data obtained from NOS contained standard deviations for the NWL-9D coordinates. However, these figures represent the internal consistencies only, and had to be increased by a common factor for subsequent use.

In those cases where no information was given at all, a standard deviation of ± 1.50 m for each component was adopted. This is in agreement with accuracy estimates obtained by comparing Doppler coordinates with those from the Transcontinental Traverse. The variances are listed in Table 2.3-5.

It is a well known fact that there is no unique way to estimate the actual accuracy of geodetic coordinates for older datums such as the North American Datum. Several empirical formulas have been published. In order to be consistent with the work reported in the Fourteenth Semiannual Status Report concerning NAD distortions, the following formula was used to estimate the standard deviations of the NAD coordinates:

$$\sigma_{(m)} = \pm \frac{1}{20000 \sqrt[3]{M_{(km)}}} \cdot M_{(m)}$$

where M is the distance between the point under consideration and the initial point of the geodetic datum. This formula was given by L. G. Simmons in an article entitled "How Accurate is the First Order Triangulation?" [The Journal, U.S. Coast and Geodetic Survey, No. 3, April 1950]. The variances are listed in Table 2.3-6.

Considering the remarks made above about certain problematic stations, there were 81 points left to use for the transformation. A preliminary plot of the stations and comparison of residuals indicated that several "nearby" stations could be also deleted without loosing information. Only stations 51072, Oil Platform - Gulf of Mexico, La., exhibited unusually large residuals and was subsequently deleted. The variances for the remaining 67 stations were scaled such that the standard deviation of unit weight, $\hat{\sigma}_0$, approached unity to within 10%. The final transformations are as follows:

a) Seven Parameter Solution (Molodensky-model)

Total number of points: 67

NAD weighting : factor = .1

NWL-9D : factor = 80

Note: Simmons formula does not give an estimate for the initial point; thus a variance of 0.20 m^2 for each axis was assumed.

(b) Three Parameters Solution : (variances as above)

The results of the above transformations to the NWL-9D system are in the table below. The notation is the same as used earlier.

Shifts	Δu	(m)	- 28.5 ± 0.41	- 28.0 ± 0.49
	Δv	(m)	153.8 ± 0.35	153.7 ± 0.42
	Δw	(m)	179.7 ± 0.34	179.8 ± 0.41
Scale	Δ	($\times 10^{-6}$)	1.76 ± 0.06	
Rotations	ω	(″)	0.30 ± 0.01	
	ψ	(″)	0.01 ± 0.01	
	ϵ	(″)	- 0.30 ± 0.02	

The after-transformation residuals are in Figures 2.3-1 through 2.3-6.

Table 2.3-1

NWL-9D Coordinates for North American Stations

		φ	λ	h (m)
10000	CHEYENNE, WY.	41° 07′ 59.″956	255° 07′ 54.″514	1857.71
10003	GREENVILLE, MISS.	33 28 42.792	0268 59 50.343	5.74
10006	MEADES RANCH, KAN.	39 13 26.627	261 27 27.505	564.67
10008	GRAND FORKS, ND	47 56 38.503	262 37 09.155	237.40
10018	JONESTOWN, TEX	30 26 48.898	262 01 15.690	291.68
10019	FRANKTON, IND	40 14 07.031	274 10 26.544	221.09
10020	MARYVILLE, IND	38 35 20.951	274 21 07.152	175.15
10021	CASH, KY	37 33 06.950	273 55 09.761	227.74
10022	IUKA, MISS	34 47 15.800	271 45 29.412	210.78
10023	WEBSTER, MISS	33 33 55.013	270 50 03.498	101.33
10028	EGLIN AFB, FL	30 34 04.883	273 47 00.484	1.547
10029	PATRICK AFB, FL	28 13 38.950	279 23 37.830	-22.184
10031	GOLDSTONE, CALIF.	35 25 39.568	243 06 36.935	981.349
10032	EDWARDS AFB, CA	34 57 50.549	242 05 06.937	746.194
10033	BUCKLEY, CO	39 43 02.094	255 13 27.054	1663.758
10045	TULA PEAK WSMR, NM	33 01 36.353	253 51 38.832	1311.808
10046	SALT WSMR, NM	33 07 12.404	253 38 09.118	1204.538
10055	PILLAR POINT, CA	37 29 53.099	237 30 04.981	11.858
10056	SAN NICHOLS, CA	33 14 48.821	240 28 46.780	234.54
10071	GALLUP, NEW MEXICO	35 31 00.596	251 24 22.212	2006.397
20001	BELTSVILLE, MD	39 01 39.814	283 10 27.104	3.08
20002	LAS CRUCES, NM	32 16 43.954	253 14 45.479	1167.637
20003	WRIGHTWOOD, CAL	34 22 54.447	242 19 05.495	2244.29
20015	WOODLINE, GA	30 56 55.695	278 19 07.737	-25.86
20016	COLUMBIA, MISS	31 12 45.099	270 16 27.059	76.35
20176	AJO, ARIZONA	32 26 54.600	247 08 51.637	399.77
20177	DOUGLAS, ARIZONA	31 22 36.952	250 27 32.654	1197.44
20208	KINGMAN, ARIZONA	35 11 48.172	245 57 31.854	1112.44
30025	BLOOMFIELD, OHIO	40 05 11.784	278 15 39.474	321.80
30026	COLUMBUS, OHIO	40 00 27.799	276 57 29.862	202.75
30027	GREENVILLE, OHIO	40 09 51.465	275 23 26.296	276.34
30028	METAMORA, ILL	40 49 20.412	270 42 39.572	211.80
30029	MOSES LAKE, WASH	47 11 06.541	240 39 43.165	338.37
30030	GREEN RIVER, UTAH	38 58 44.214	249 53 17.276	1288.256
30038	BLAINE, WASHINGTON	48 54 47.191	237 15 47.432	-10.94
30078	WESTFORD, MASS	42 37 04.258	288 30 31.810	105.33
30098	ORLAND, CALIFORNIA	39 44 44.086	237 50 53.043	32.464
30099	CHANCE1967, MONTANA	47 47 07.425	251 22 04.173	984.20
51004	CHARLESTON, WV	38 22 10.835	278 24 32.776	249.382
51005	CORBIN, KENTUCKY	36 57 21.781	275 53 08.520	354.976
51006	CLEVELAND, TENNES.	35 09 06.961	275 06 55.188	261.137
51007	LAURENS, SOUTH CAR.	34 35 08.446	277 56 35.479	182.541
51008	BOLIVIA, NORTH CAR.	34 02 10.816	281 50 39.664	-34.318
51009	SHELBY, ALABAMA	33 07 03.355	273 30 00.801	181.752
51010	SANDERSVILLE, G.	33 03 38.462	277 05 29.905	112.977
51011	FARMVILLE, VIRGINIA	37 18 52.043	281 33 38.270	102.434
51012	BONIFAY, FLORIDA	30 39 05.829	274 11 37.636	-6.31
51013	CLEARWATER-ST.P.FL	27 55 13.006	277 18 24.529	-32.083
51014	VALKARIA, FLORIDA	27 57 26.282	279 26 31.981	-30.265
51015	HIALEAH, FLORIDA	25 53 26.196	279 41 34.325	-28.143
51017	MIFFLINVILLE, PA	41 00 57.788	283 39 42.036	256.467
51019	HUDSON, N.Y.	42 14 37.676	286 13 24.447	72.477

Table 2.3-1 (Continued)

		φ	λ	h (m)
51020	ALBURG(GSC),VER.	44° 54′ 29.″267	286° 42′ 30.″669	29.527
51021	ORLEANS,MASS	41 51 19.234	290 02 59.201	-19.649
51022	FAIRFIELD,ME	44 35 59.522	290 24 46.393	7.587
51023	BOUCHARD RM2,MAINE	47 11 53.912	291 26 48.671	326.393
51024	FREEPORT,TX	29 02 31.525	264 39 49.664	-31.911
51025	NEWTON,TEXAS	30 54 24.714	266 23 55.765	49.897
51026	CLARKSVILLE,TEXAS	33 38 22.877	264 58 55.424	117.625
51027	SPRINGDALE,ARK.	36 10 23.417	265 52 39.252	374.242
51028	THAYER,MISSOURI	36 34 37.098	268 22 23.142	259.787
51029	PLATTE CITY,MO	39 16 50.854	265 13 49.562	261.807
51030	KINGFISHER,OKLAH	35 47 01.478	262 01 11.075	327.349
51031	CLAY CITY,ILL	38 38 14.569	271 39 00.669	105.314
51032	EL DARA,ILL	39 37 27.900	268 58 33.650	201.181
51033	WOODBINE,IOWA	41 42 12.609	264 21 19.399	389.342
51041	MEYER 1946,NEB	41 38 26.726	258 24 01.345	1151.98
51043	LAKE 1957,WY	44 48 01.457	251 39 16.310	1192.35
51044	HORSE 1972,WY	41 36 55.678	252 12 53.888	2208.722
51056	KEARNS,UTAH	40 38 36.160	248 01 42.569	1369.895
51057	DRY 1965,NEVADA	40 23 41.717	244 47 30.933	1828.559
51058	DIATOM 1958,NEVADA	39 49 37.575	241 00 52.340	1275.178
52063	DOS PALOS,CA	36 54 50.765	239 26 44.563	-1.310
53063	DOS PALOS,CA	36 54 50.743	239 26 44.530	-1.437
51066	TERREBONNE,OREGON	44 23 31.282	238 42 12.208	861.277
51067	MINERAL WELLS,TEX	32 57 44.997	261 54 35.104	323.845
51068	YULEE,FLORIDA	30 41 46.311	278 15 59.114	-19.419
51069	ASHEPOO,S.C.	32 45 31.674	279 26 36.774	-38.685
51070	WRIGHTWOOD,CALIF.	34 22 44.387	242 19 05.134	2153.871
51072	OIL PLATFORM,LA	28 56 22.056	276 15 10.521	-4.551
51074	MIDLAND,OR	42 07 21.398	238 10 21.891	1218.160
51081	UPPER 1965,MICH.	46 18 30.359	274 32 35.124	216.647
51082	LITTLE RM1,MICH.	43 44 11.082	275 11 32.141	238.112
51089	MAYHOOD 1971,CALIF	38 08 31.754	238 16 33.529	10.232
51095	AGAMENTICUS,MAINE	43 13 24.265	289 18 28.169	175.472
52001	BELTSVILLE,MARYL	39 01 39.775	283 10 27.054	-0.485
52002	BELTSVILLE,MARYL	39 01 39.293	283 10 27.278	1.687
60001	BELTSVILLE,MD	39 01 39.779	283 10 27.054	0.447
90008	???,ARIZONA	32 39 11.004	245 24 29.186	40.71

Table 2.3-2

NWL-9D Coordinates for North American Stations

	X(m)	Y(m)	Z(m)
10000	-1234810.34479	-4651148.68714	4174812.84885
10003	-93190.22405	-5324578.26616	3498357.53337
10006	-734990.46861	-4893186.64195	4011979.40879
10008	-549887.01523	-4245038.24274	4712891.39485
10018	-763949.81704	-5450296.58834	3213333.93701
10019	354909.62027	-4863115.05179	4098111.72536
10020	378813.81379	-4977652.25554	3956883.44462
10021	346075.33324	-5051239.60916	3866278.25302
10022	160893.78147	-5241609.73580	3618675.36159
10023	77466.09114	-5319596.99528	3506429.79645
10028	362692.68467	-5484531.06898	3224754.30961
10029	917920.73638	-5548410.67279	2998733.93464
10031	-2353582.30711	-4641223.76242	3677203.67495
10032	-2450021.89427	-4624408.97654	3635030.06239
10033	-1253284.35437	-4751609.95914	4054954.02422
10045	-1488252.93036	-5142959.85546	3457166.54839
10046	-1506813.25660	-5131569.83846	3465785.07069
10055	-2722152.23814	-4273150.81962	3861406.85452
10056	-2631050.99977	-4646517.58020	3477023.60556
10071	-1657728.05935	-4927594.52800	3685857.92988
20001	1130764.10147	-4830822.62934	3994715.06391
20002	-1556220.62943	-5169436.28406	3387244.13678
20003	-2448848.33412	-4667969.51863	3582748.89299
20015	792114.42740	-5417292.09969	3261017.23183
20016	26127.64213	-5459827.53282	3286111.78910
20176	-2092423.34076	-4964981.48058	3402723.38344
20177	-1823377.95546	-5137394.44202	3302271.79881
20208	-2126098.53690	-4766079.94095	3656367.81594
30025	702141.41918	-4836067.60863	4085559.51361
30026	592688.90427	-4856284.12728	4078777.27857
30027	458565.44577	-4859590.95856	4092126.36406
30028	59980.32619	-4833306.24006	4147655.93697
30029	-2127824.96370	-3785852.43423	4656031.95123
30030	-1707513.13264	-4663005.92492	3991315.35939
30038	-2271129.67549	-3532651.75399	4784210.85529
30078	1492300.44823	-4457731.14319	4296433.64456
30098	-2613387.68066	-4157720.62551	4056330.75583
30099	-1371924.26386	-4069030.48968	4701610.99752
51004	732263.41817	-4953431.48498	3937856.75521
51005	523305.69429	-5076315.22859	3813714.44134
51006	465504.94379	-5200166.84308	3651815.98075
51007	726444.68845	-5206374.95067	3600228.55228
51008	1085993.59359	-5178330.35168	3549772.19384
51009	326478.96891	-5337543.79675	3464992.73182
51010	660605.36604	-5309973.17219	3459666.56586
51011	1017856.33785	-4975965.47110	3845273.01778
51012	401614.56491	-5477079.93053	3232726.60242
51013	717289.41982	-5594041.54702	2968690.23123
51014	924916.88205	-5561535.20681	2972315.52571
51015	966695.26915	-5659642.01745	2768155.16523
51017	1138337.87655	-4683261.00483	4163941.43212
51019	1321178.95323	-4540588.28022	4265743.21216

Table 2.3-2 (Continued)

	X(m)	Y(m)	Z(m)
51020	1300902.22758	-4333791.68425	4480149.24505
51021	1631121.89077	-4469385.10750	4233641.57170
51022	1586590.26501	-4263277.41136	4455807.10314
51023	1587514.48558	-4041129.01323	4657017.32931
51024	-518990.17029	-5556368.82666	3077968.50440
51025	-344038.01084	-5466536.55310	3257067.55379
51026	-464943.50883	-5295234.36211	3513312.70175
51027	-370581.45088	-5141652.18507	3743945.08865
51028	-145598.35752	-5126254.61386	3779956.29377
51029	-411074.58993	-4926739.43748	4016665.17115
51030	-719196.02498	-5130171.71830	3708948.19848
51031	143659.13081	-4986581.31819	3961023.14441
51032	-87917.51068	-4918783.49404	4046085.67069
51033	-469094.58885	-4746142.64147	4221337.38980
51041	-960010.38566	-4676960.75679	4216638.28646
51043	-1427089.14345	-4303659.34812	4472482.73584
51044	-1459157.32103	-4548825.60091	4215240.07808
51056	-1813679.78182	-4495449.79318	4133350.65657
51057	-2072378.89625	-4402418.88813	4112669.95257
51058	-2377392.28887	-4291497.04963	4064082.40225
52063	-2595520.92498	-4396788.44576	3809779.14754
53063	-2595521.78387	-4396788.29383	3809778.52903
51066	-2371753.82195	-3901369.89640	4439929.85159
51067	-753907.72463	-5303702.30432	3450649.92098
51068	789224.05276	-5437220.05147	3236970.55862
51069	880918.03063	-5296209.15464	3431476.64619
51070	-2448903.18382	-4668054.21314	3582441.91265
51072	608423.53781	-5552858.42244	3068032.01801
51074	-2499045.55974	-4026270.50591	4256536.73841
51081	349607.90968	-4399882.09211	4589158.33848
51082	417734.61088	-4597009.49347	4387147.00671
51089	-2641085.10147	-4272274.06522	3917876.46313
51095	1539185.82105	-4393301.31088	4345745.53359
52001	1130762.47186	-4830820.94428	3994711.88475
52002	1130770.22580	-4830830.47253	3994701.70560
60001	1130762.61917	-4830821.57361	3994712.56745
90008	-2236973.31784	-4887800.63011	3421652.06989

Table 2.3-3

NAD-1927 Coordinates for North American Stations

Station	Name	φ	λ	h(m)
10000	CHEYENNE, WY.	41° 08′ 00.″0691	255° 07′ 57.″2024	1889.5
10003	GREENVILLE, MISS.	33 28 42.4696	268 59 51.4859	44.2
10006	MEADES RANCH, KAN.	39 13 26.686	261 27 29.494	599.4
10008	GRAND FORKS, ND	47 56 38.594	262 37 11.201	274.0
10018	JONESTOWN, TEX	30 26 48.273	262 01 17.525	327.1
10019	FRANKTON, IND	40 14 06.956	274 10 27.186	259.0
10020	MARYVILLE, IND	38 35 20.787	274 21 07.740	212.6
10021	CASH, KY	37 33 06.807	273 55 10.384	264.5
10022	IUKA, MISS	34 47 15.547	271 45 30.291	250.4
10023	WEBSTER, MISS	33 33 54.655	270 50 04.504	141.3
10028	EGLIN AFB, FL	30 34 04.343	273 47 01.078	40.9
10029	PATRICK AFB, FL	28 13 38.0841	279 23 37.8193	16.3
10031	GOLDSTONE, CALIF.	35 25 39.8183	243 06 40.9729	994.0
10032	EDWARS AFB, CA	34 57 50.7427	242 05 11.0552	758.4
10033	BUCKLEY, CO	39 43 02.208	255 13 29.785	1691.1
10045	TULA PEAK WSMR, NM	33 01 36.2140	253 51 41.7115	1338.8
10046	SALT WSMR, NM	33 07 12.2215	253 38 12.0076	1233.3
10055	PILLAR POINT, CA	37 29 53.441	237 30 09.749	21.0
10056	SAN NICHOLS, CA	33 14 48.875	240 28 50.994	248.3
10071	GALLUP, NEW MEXICO	35 31 00.605	251 24 25.292	2030.6
20001	BELTSVILLE, MD	39 01 39.4916	283 10 26.7558	40.1
20002	LAS CRUCES, NM	32 16 43.702	253 14 48.285	1196.4
20003	WRIGHTWOOD, CAL	34 22 54.537	242 19 09.484	2256.6
20015	WOODLINE, GA	30 56 54.982	278 19 07.845	11.6
20016	COLUMBIA, MISS	31 12 44.555	270 16 28.098	113.6
20176	AJO, ARIZONA	32 26 54.473	247 08 54.990	422.9
20177	DOUGLAS, ARIZONA	31 22 36.699	250 27 35.724	1225.0
20208	KINGMAN, ARIZONA	35 11 48.275	245 57 35.557	1130.7
30025	BLOOMFIELD, OHIO	40 05 11.583	278 15 39.706	360.6
30026	COLUMBUS. OHIO	40 00 27.649	276 57 30.248	240.2
30027	GREENVILLE. OHIO	40 09 51.348	275 23 26.854	313.5
30028	METAMORA. ILL	40 49 20.343	270 42 40.598	249.0
30029	MOSES LAKE, WASH.	47 11 07.132	240 39 48.118	355.0
30030	GREEN RIVER, UTAH	38 58 44.361	249 53 20.567	1311.1
30038	BLAINE, WASHINGTON	48 54 47.8803	237 15 52.8636	5.1
30078	WESTFORD. MASS	42 37 04.0839	288 30 30.8808	141.0
30098	ORLAND, CALIFORNIA	39 44 44.602	237 50 57.839	42.6
30099	CHANCE1967, MONTANA	47 47 07.507	251 22 07.573	1011.9
51004	CHARLESTON, WV	38 22 10.576	278 24 33.038	290.7
51005	CORBIN, KENTUCKY	36 57 21.573	275 53 09.046	394.51
51006	CLEVELAND, TENNES.	35 09 06.794	275 06 55.814	303.01
51007	LAURENS, SOUTH CAR.	34 35 08.0877	277 56 35.6847	224.20
51008	BOLIVIA, NORTH CAR.	34 02 10.298	281 50 39.478	6.8
51009	SHELBY, ALABAMA	33 07 03.0277	273 30 01.5046	222.7
51010	SANDERSVILLE, G.	33 03 38.048	277 05 30.233	154.05
51011	FARMVILLE, VIRGINIA	37 18 51.5955	281 33 38.4097	142.5
51012	BONIFAY, FLORIDA	30 39 05.274	274 11 38.206	34.70
51013	CLEARWATER-ST.P.FL	27 55 12.034	277 18 24.707	10.40
51014	VALKARIA. FLORIDA	27 57 25.330	279 26 31.977	13.258
51015	HIALEAH, FLORIDA	25 53 24.868	279 41 34.285	16.3
51017	MIFFLINVILLE, PA	41 00 57.554	283 39 41.596	295.8
51019	HUDSON, N.Y.	42 14 37.446	286 13 23.691	112.12

Table 2.3-3 (Continued)

		φ	λ	h(m)
51020	ALBURG(GSC),VER.	44° 54′ 29″.145	286° 42′ 29″.965	66.8
51021	ORLEANS,MASS	41 51 18.929	290 02 58.042	18.54
51022	FAIRFIELD,ME	44 35 59.3572	290 24 45.3246	45.827
51023	BOUCHARD RM2,MAINE	47 11 53.849	291 26 47.633	362.0
51024	FREEPORT,TX	29 02 30.776	264 39 51.252	5.68
51025	NEWTON,TEXAS	30 54 24.116	266 23 57.198	87.8
51026	CLARKSVILLE,TEXAS	33 38 22.616	264 58 57.010	153.1
51027	SPRINGDALE,ARK.	36 10 23.216	265 52 40.709	412.3
51028	THAYER,MISSOURI	36 34 36.984	268 22 24.460	296.82
51029	PLATTE CITY.MO	39 16 50.961	265 13 51.216	300.00
51030	KINGFISHER,OKLAH	35 47 01.393	262 01 13.051	363.0
51031	CLAY CITY,ILL	38 38 14.4738	271 39 01.6445	144.16
51032	EL DARA,ILL	39 37 27.816	268 58 34.875	240.24
51033	WOODBINE,IOWA	41 42 12.717	264 21 21.183	425.5
51041	MEYER 1946,NEB	41 38 26.878	258 24 03.785	1184.0
51043	LAKE 1957,WY	44 48 01.705	251 39 19.481	1220.35
51044	HORSE 1972,WY	41 36 55.887	252 12 56.957	2236.5
51056	KEARNS ,UTAH	40 38 36.430	248 01 46.128	1392.1
51057	DRY 1965,NEVADA	40 23 42.057	244 47 34.864	1847.62
51058	DIATOM 1958,NEVADA	39 49 37.992	241 00 56.736	1290.9
52063	DOS PALOS,CA	36 54 51.030	239 26 48.988	9.68
53063	DOS PALOS,CA	36 54 51.030	239 26 48.988	9.68
51066	TERREBONNE,OREGON	44 23 31.948	238 42 17.210	874.9
51067	MINERAL WELLS,TEX	32 57 44.684	261 54 37.082	357.6
51068	YULEE,FLORIDA	30 41 45.5832	278 15 59.260	21.4
51069	ASHEPOO,S.C.	32 45 31.1419	279 26 36.9271	1.9
51070	WRIGHTWOOD,CALIF.	34 22 44.4413	242 19 09.2715	2172.77
51072	OIL PLATFORM,LA	28 56 21.335	276 15 11.898	32.1
51074	MIDLAND,OR	42 07 21.955	238 10 26.638	1229.88
51089	MAYHOOD 1971,CALIF	38 08 32.163	238 16 38.179	21.10
51095	AGAMENTICUS,MAINE	43 13 24.048	289 18 27.146	211.4
52001	BELTSVILLE,MARYL	39 01 39.4916	283 10 26.7558	40.1
52002	BELTSVILLE,MARYL	39 01 39.0030	283 10 26.9420	40.1
60001	BELTSVILLE,MD	39 01 39.4916	283 10 26.7558	40.1
90008	???,ARIZONA	32 39 10.828	245 24 32.847	61.3

Note: The coordinates of station 51081 (Newberry, Michigan) and 51082 (Rosebush, Michigan) are not given since the elevation of the mark above MSL is not available at this date.

Table 2.3-4

NAD-1927 Coordinates for North American Stations

	X(m)	Y(m)	Z(m)
10000	-1234787.01287	-4651305.24820	4174632.26703
10003	-93163.3274	-5324727.7588	3498182.6345
10006	-734965.10287	-4893338.99853	4011801.66913
10008	-549864.35647	-4245193.85197	4712710.80810
10018	-763921.55654	-5450447.70184	3213157.09664
10019	354935.89169	-4863266.51618	4097931.65607
10020	378839.58697	-4977803.37641	3956702.89265
10021	346100.87337	-5051388.65185	3866099.25380
10022	160920.74798	-5241759.84364	3618500.13789
10023	77494.23557	-5319747.61046	3506254.62638
10028	362718.24714	-5484677.72920	3224581.38896
10029	917944.49834	-5548556.09040	2998558.65948
10031	-2353546.10986	-4641377.63202	3677024.23533
10032	-2449986.10613	-4624564.61870	3634850.06573
10033	-1253257.28417	-4751762.52618	4054772.24688
10045	-1488218.80804	-5143110.83040	3456991.15919
10046	-1506780.22231	-5131723.27751	3465609.29068
10055	-2722117.58595	-4273314.41220	3861222.98818
10056	-2631015.98190	-4646677.14191	3476845.38285
10071	-1657697.43448	-4927746.97241	3685678.93531
20001	1130791.47330	-4830976.31625	3994529.88936
20002	-1556189.96316	-5169589.19696	3387068.69774
20003	-2448814.60620	-4668124.67174	3582567.78721
20015	792138.94872	-5417439.98761	3260837.74799
20016	26155.85120	-5459974.93349	3285935.96242
20176	-2092393.53049	-4965136.27632	3402547.73088
20177	-1823346.61493	-5137548.72238	3302098.14912
20208	-2126064.99762	-4766234.73910	3656188.45587
30025	702169.27593	-4836221.21900	4085376.99993
30026	592716.63644	-4856435.77982	4078595.38194
30027	458592.98239	-4859742.21159	4091944.89497
30028	60006.26530	-4833458.77091	4147474.96655
30029	-2127796.09549	-3786013.91927	4655847.15013
30030	-1707485.39103	-4663160.59124	3991132.57877
30038	-2271103.52778	-3532815.59222	4784027.11280
30078	1492329.65190	-4457885.09067	4296247.84148
30098	-2613354.59563	-4157882.56192	4056147.47172
30099	-1371903.72852	-4069191.13759	4701423.61322
51004	732292.70433	-4953586.09926	3937676.59777
51005	523334.33832	-5076466.17623	3813536.44814
51006	465534.30520	-5200516.56071	3651643.51554
51007	726471.17226	-5206526.82108	3600052.21709
51008	1086020.84071	-5178483.49970	3549592.57927
51009	326506.36836	-5337692.95772	3464819.88045
51010	660632.57821	-5310122.98023	3459491.67290
51011	1017891.46347	-4976120.02327	3845089.92317
51012	401640.65947	-5477228.26993	3232553.90268
51013	717313.54522	-5594191.42876	2968514.90610
51014	924941.78326	-5561685.60454	2972141.11812
51015	966720.05300	-5659793.73112	2767977.48766
51017	1138365.19529	-4683416.92001	4163757.84166
51019	1321206.75726	-4540745.87589	4265559.04429

Table 2.3-4 (Continued)

	X(m)	Y(m)	Z(m)
51020	1300932.42103	-4333945.98825	4479964.74932
51021	1631151.37676	-4469543.88152	4233454.95837
51022	1586623.28185	-4263433.68813	4455622.42510
51023	1587550.58235	-4041280.65898	4656832.72282
51024	-518961.02488	-5556518.78229	3077793.47765
51025	-344009.35009	-5466687.00629	3256891.44616
51026	-464915.53902	-5295383.11407	3513137.36851
51027	-370555.96439	-5141805.11752	3743767.68838
51028	-145569.82647	-5126404.32935	3779779.74733
51029	-411047.44629	-4926890.91895	4016490.69597
51030	-719167.16105	-5130323.29882	3708772.98525
51031	143687.10534	-4986733.03793	3960845.05825
51032	-87891.03953	-4918937.43898	4045906.78638
51033	-469068.20706	-4746295.11729	4221159.04138
51041	-959984.23416	-4677114.25299	4216458.25801
51043	-1427067.38845	-4303815.21224	4472299.13266
51044	-1459132.62716	-4548981.33003	4215058.57208
51056	-1813652.53308	-4495605.81371	4133168.02645
51057	-2072350.55979	-4402576.42778	4112487.25633
51058	-2377361.79737	-4291657.78291	4063900.21512
52063	-2595488.33949	-4396948.71761	3809595.73462
53063	-2595488.33949	-4396948.71761	3809595.73462
51066	-2371722.77412	-3901531.97290	4439746.33500
51067	-753877.13100	-5303852.11993	3450473.87748
51068	789249.82219	-5432370.39721	3236793.06675
51069	880947.07468	-5296359.48282	3431299.11481
51070	-2448868.90626	-4668216.49201	3582263.62636
51072	608476.41708	-5552998.63492	3067857.59850
51074	-2499017.23397	-4026431.67655	4256351.92947
51089	-2641052.03915	-4272435.92691	3917693.99328
51095	1539215.86721	-4393456.87232	4345558.60275
52001	1130791.47330	-4830976.31625	3994529.88936
52002	1130797.99669	-4830984.53345	3994518.16455
60001	1130791.47330	-4830976.31625	3994529.88936
90008	-2236940.70811	-4887958.64470	3421473.22711

Table 2.3-5

Variances of the NWL-9D Coordinates

	σ_x^2 (m^2)	σ_y^2 (m^2)	σ_z^2 (m^2)
10000	0.165600D+01	0.165600D+01	0.165600D+01
10003	0.311400D+01	0.311400D+01	0.311400D+01
10006	0.200000D+00	0.200000D+00	0.200000D+00
10008	0.330600D+01	0.330600D+01	0.330600D+01
10018	0.331800D+01	0.331800D+01	0.331800D+01
10019	0.386900D+01	0.386900D+01	0.386900D+01
10020	0.398200D+01	0.398200D+01	0.398200D+01
10022	0.361200D+01	0.361200D+01	0.361200D+01
10031	0.680600D+01	0.680600D+01	0.680600D+01
10045	0.328300D+01	0.328300D+01	0.328300D+01
10055	0.915800D+01	0.915800D+01	0.915800D+01
10056	0.857500D+01	0.857500D+01	0.857500D+01
10071	0.334100D+01	0.334100D+01	0.334100D+01
20001	0.788500D+01	0.788500D+01	0.788500D+01
20016	0.435600D+01	0.435600D+01	0.435600D+01
20176	0.583700D+01	0.583700D+01	0.583700D+01
20177	0.498400D+01	0.498400D+01	0.498400D+01
20208	0.559500D+01	0.559500D+01	0.559500D+01
30025	0.558000D+01	0.558000D+01	0.558000D+01
30028	0.259100D+01	0.259100D+01	0.259100D+01
30029	0.802800D+01	0.802800D+01	0.802800D+01
30030	0.343400D+01	0.343400D+01	0.343400D+01
30038	0.978100D+01	0.978100D+01	0.978100D+01
30098	0.876100D+01	0.876100D+01	0.876100D+01
30099	0.462400D+01	0.462400D+01	0.462400D+01
51004	0.574600D+01	0.574600D+01	0.574600D+01
51005	0.480200D+01	0.480200D+01	0.480200D+01
51006	0.481600D+01	0.481600D+01	0.481600D+01
51007	0.616200D+01	0.616200D+01	0.616200D+01
51008	0.808200D+01	0.808200D+01	0.808200D+01
51009	0.474700D+01	0.474700D+01	0.474700D+01
51010	0.619400D+01	0.619400D+01	0.619400D+01
51011	0.731000D+01	0.731000D+01	0.731000D+01
51012	0.588300D+01	0.588300D+01	0.588300D+01
51013	0.819000D+01	0.819000D+01	0.819000D+01
51014	0.906300D+01	0.906300D+01	0.906300D+01
51015	0.100800D+02	0.100800D+02	0.100800D+02
51017	0.802800D+01	0.802800D+01	0.802800D+01
51019	0.923500D+01	0.923500D+01	0.923500D+01
51021	0.111090D+02	0.111090D+02	0.111090D+02
51022	0.113210D+02	0.113210D+02	0.113210D+02
51024	0.421200D+01	0.421200D+01	0.421200D+01
51025	0.355200D+01	0.355200D+01	0.355200D+01
51026	0.211600D+01	0.211600D+01	0.211600D+01
51027	0.142100D+01	0.142100D+01	0.142100D+01
51028	0.203400D+01	0.203400D+01	0.203400D+01
51029	0.767000D+00	0.767000D+00	0.767000D+00
51030	0.961000D+00	0.961000D+00	0.961000D+00
51031	0.291600D+01	0.291600D+01	0.291600D+01
51032	0.192700D+01	0.192700D+01	0.192700D+01
51033	0.906000D+00	0.906000D+00	0.906000D+00
52063	0.828100D+01	0.828100D+01	0.828100D+01
51066	0.842700D+01	0.842700D+01	0.842700D+01
51067	0.211600D+01	0.211600D+01	0.211600D+01
51068	0.748200D+01	0.748200D+01	0.748200D+01
51069	0.731000D+01	0.731000D+01	0.731000D+01
51074	0.853800D+01	0.853800D+01	0.853800D+01
51020	0.980000D+00	0.980000D+00	0.980000D+00
51023	0.109600D+01	0.109600D+01	0.109600D+01
51041	0.304000D+00	0.304000D+00	0.304000D+00
51043	0.593000D+00	0.593000D+00	0.593000D+00
51044	0.516000D+00	0.516000D+00	0.516000D+00
51056	0.645000D+00	0.645000D+00	0.645000D+00
51057	0.743000D+00	0.743000D+00	0.743000D+00
51058	0.851000D+00	0.851000D+00	0.851000D+00
51089	0.932000D+00	0.932000D+00	0.932000D+00
51095	0.103600D+01	0.103600D+01	0.103600D+01

Table 2.3-6

Variances of the NAD-27 Coordinates

	σ_x^2 (m^2)	σ_y^2 (m^2)	σ_z^2 (m^2)
10000	0.560000D+01	0.264000D+01	0.248000D+01
10003	0.136000D+01	0.480000D+00	0.480000D+00
10006	0.232000D+01	0.104000D+01	0.104000D+01
10008	0.496000D+01	0.200000D+01	0.192000D+01
10018	0.256000D+01	0.960000D+00	0.960000D+00
10019	0.208000D+01	0.800000D+00	0.800000D+00
10020	0.456000D+01	0.192000D+01	0.192000D+01
10022	0.134400D+02	0.440000D+01	0.488000D+01
10031	0.167040D+03	0.102160D+03	0.812000D+02
10045	0.996800D+02	0.483200D+02	0.416800D+02
10055	0.225000D+01	0.225000D+01	0.225000D+01
10056	0.969600D+02	0.620000D+02	0.424800D+02
10071	0.100000D+01	0.100000D+01	0.100000D+01
20001	0.312000D+01	0.128000D+01	0.112000D+01
20016	0.256000D+01	0.104000D+01	0.112000D+01
20176	0.100000D+01	0.100000D+01	0.100000D+01
20177	0.100000D+01	0.100000D+01	0.100000D+01
20208	0.400000D+01	0.400000D+01	0.400000D+01
30025	0.456000D+01	0.192000D+01	0.192000D+01
30028	0.816000D+01	0.280000D+01	0.272000D+01
30029	0.312000D+01	0.232000D+01	0.200000D+01
30030	0.392000D+01	0.208000D+01	0.184000D+01
30038	0.472000D+01	0.320000D+01	0.216000D+01
30098	0.100000D+01	0.100000D+01	0.100000D+01
30099	0.512000D+01	0.256000D+01	0.216000D+01
51004	0.576000D+01	0.224000D+01	0.224000D+01
51005	0.456000D+01	0.192000D+01	0.192000D+01
51006	0.536000D+01	0.208000D+01	0.208000D+01
51007	0.126400D+02	0.448000D+01	0.448000D+01
51008	0.528000D+01	0.248000D+01	0.232000D+01
51009	0.225000D+01	0.225000D+01	0.225000D+01
51010	0.225000D+01	0.225000D+01	0.225000D+01
51011	0.568000D+01	0.248000D+01	0.232000D+01
51012	0.225000D+01	0.225000D+01	0.225000D+01
51013	0.225000D+01	0.225000D+01	0.225000D+01
51014	0.225000D+01	0.225000D+01	0.225000D+01
51015	0.225000D+01	0.225000D+01	0.225000D+01
51017	0.376000D+01	0.152000D+01	0.136000D+01
51019	0.336000D+01	0.152000D+01	0.136000D+01
51021	0.225000D+01	0.225000D+01	0.225000D+01
51022	0.225000D+01	0.225000D+01	0.225000D+01
51024	0.320000D+01	0.136000D+01	0.136000D+01
51025	0.624000D+01	0.216000D+01	0.224000D+01
51026	0.288000D+01	0.120000D+01	0.112000D+01
51027	0.872000D+01	0.304000D+01	0.312000D+01
51028	0.225000D+01	0.225000D+01	0.225000D+01
51029	0.225000D+01	0.225000D+01	0.225000D+01
51030	0.120000D+02	0.472000D+01	0.464000D+01
51031	0.225000D+01	0.225000D+01	0.225000D+01
51032	0.225000D+01	0.225000D+01	0.225000D+01
51033	0.225000D+01	0.225000D+01	0.225000D+01
52063	0.224000D+01	0.152000D+01	0.112000D+01
51066	0.352000D+01	0.232000D+01	0.160000D+01
51067	0.416000D+01	0.168000D+01	0.176000D+01
51068	0.288000D+01	0.120000D+01	0.112000D+01
51069	0.312000D+01	0.128000D+01	0.128000D+01
51074	0.121600D+02	0.792000D+01	0.520000D+01
51020	0.585000D+01	0.387000D+01	0.369000D+01
51023	0.396000D+01	0.198000D+01	0.162000D+01
51041	0.315000D+01	0.144000D+01	0.144000D+01
51043	0.333000D+01	0.153000D+01	0.126000D+01
51044	0.333000D+01	0.135000D+01	0.108000D+01
51056	0.648000D+01	0.333000D+01	0.279000D+01
51057	0.675000D+01	0.378000D+01	0.288000D+01
51058	0.342000D+01	0.207000D+01	0.153000D+01
51089	0.432000D+01	0.297000D+01	0.216000D+01
51095	0.369000D+01	0.162000D+01	0.126000D+01

RESIDUALS

3 Parameter Transformation (NWL9D - NAD): Latitude

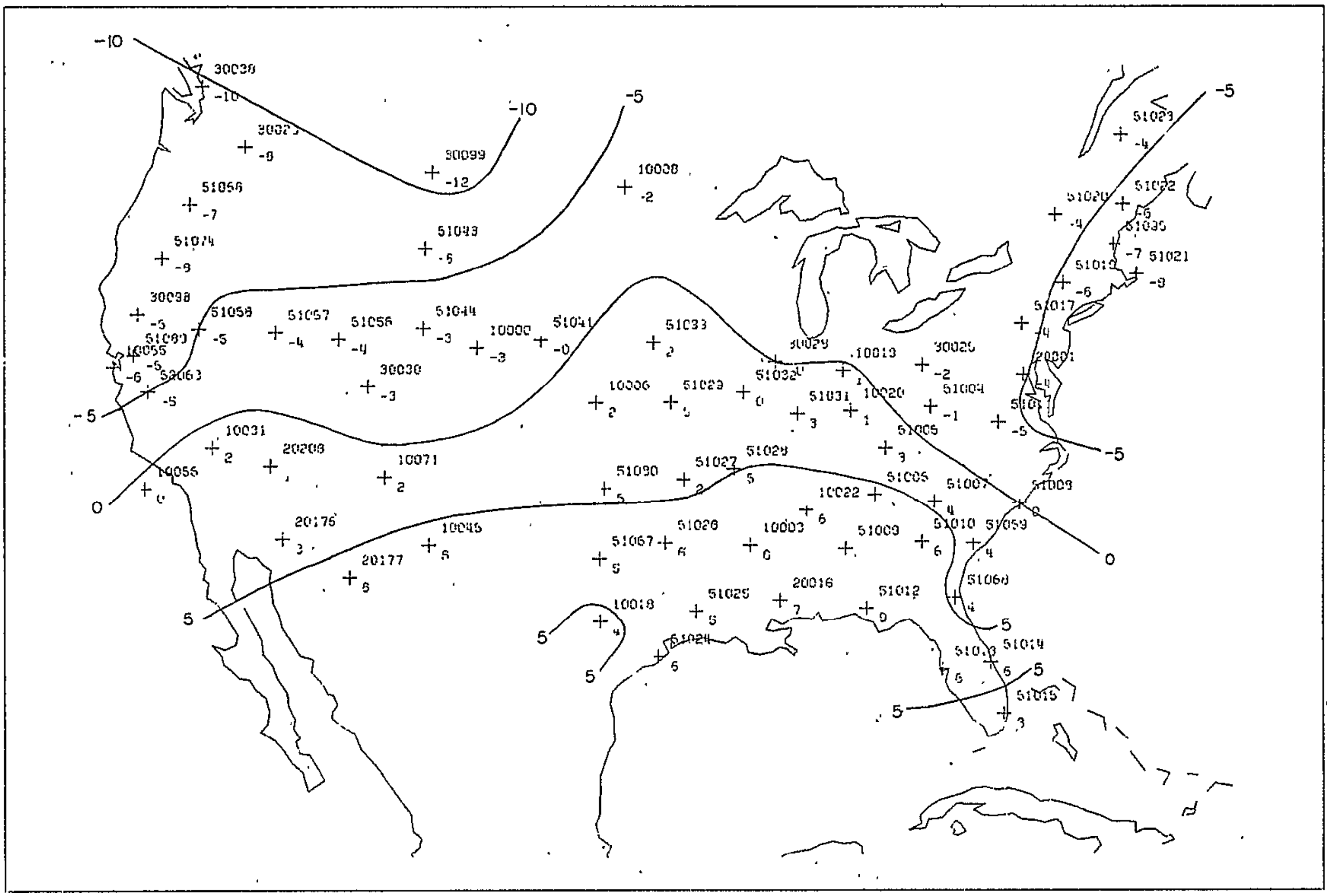


Figure 2.3-1

RESIDUALS

3 Parameter Transformation (NWL9D - NAD): Longitude

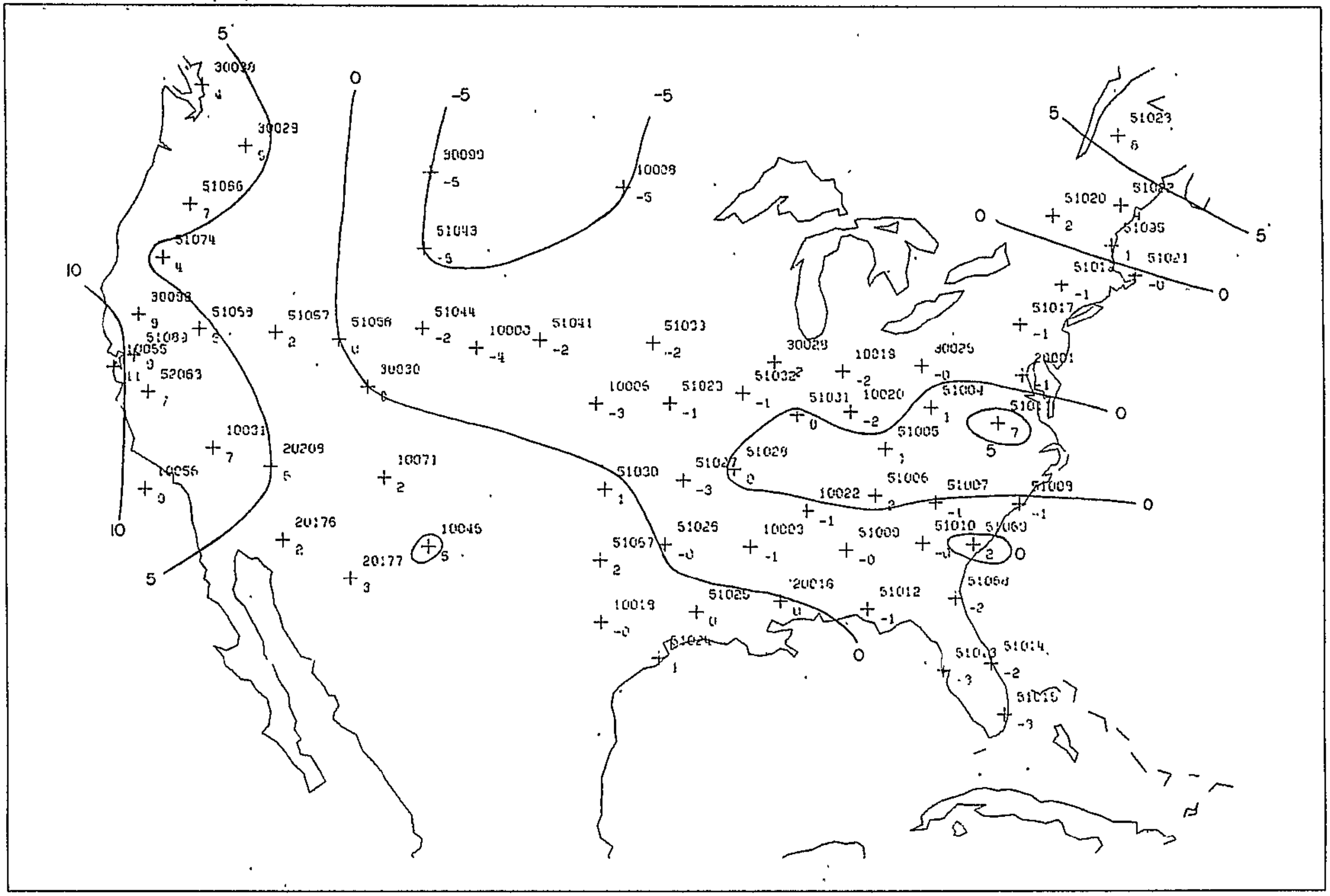
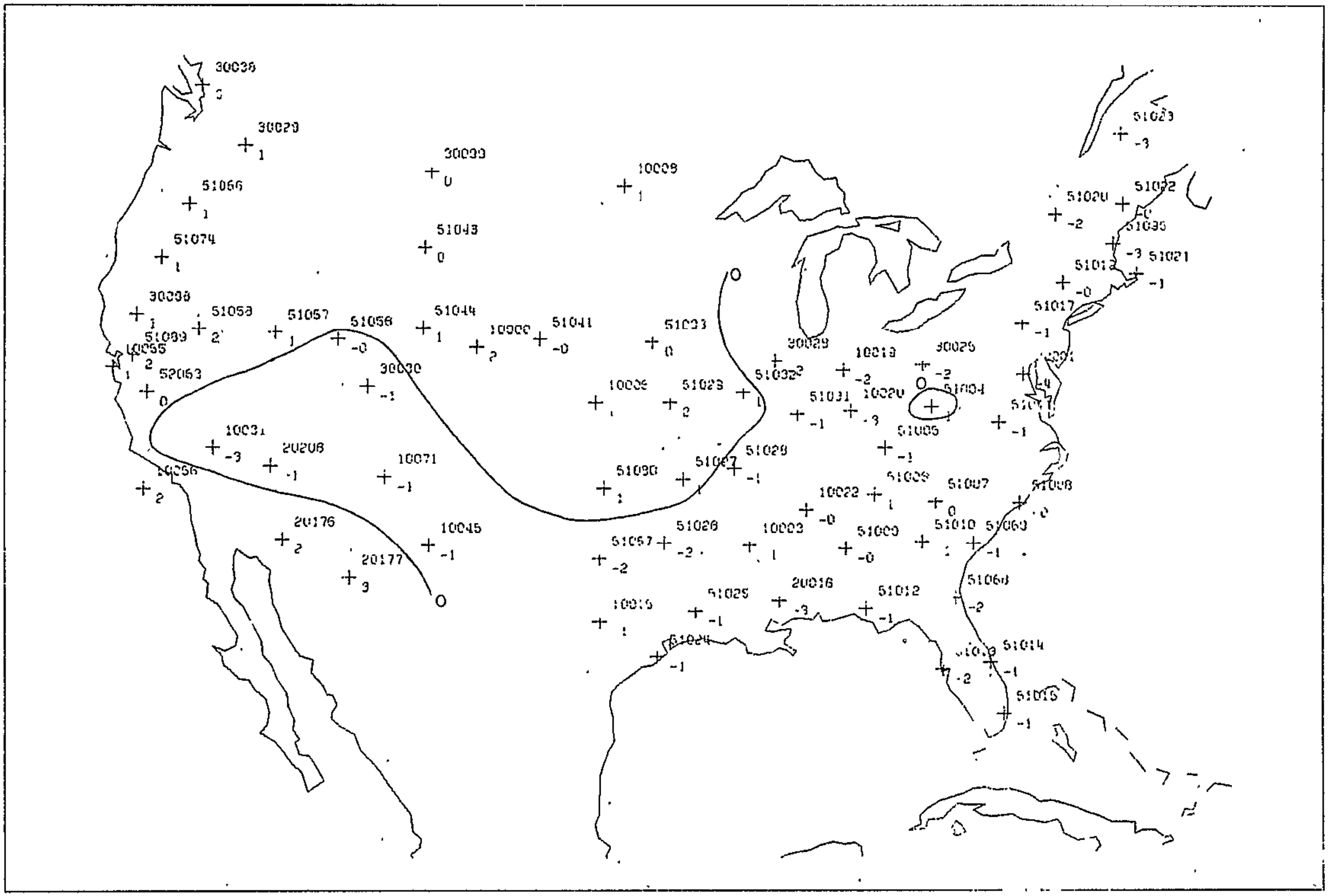


Figure 2.3-2

RESIDUALS

3 Parameter Transformation (NWL9D - NAD): Height



<u>Figure 2.3-3</u>

RESIDUALS

7 Parameter Transformation (NWL9D -NAD): Latitude

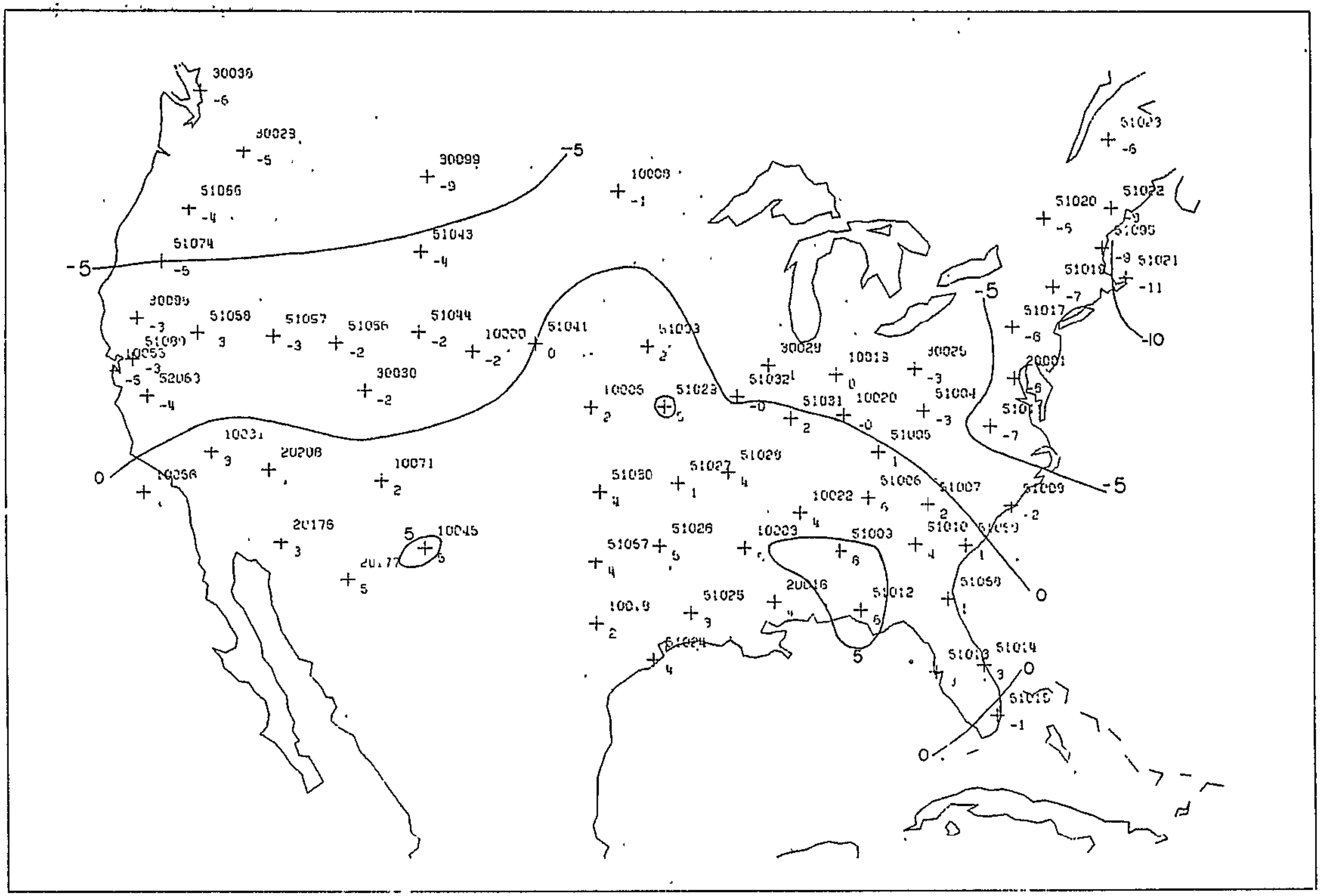


Figure 2.3-4

RESIDUALS

7 Parameter Transformation (NWL9D - NAD): Longitude

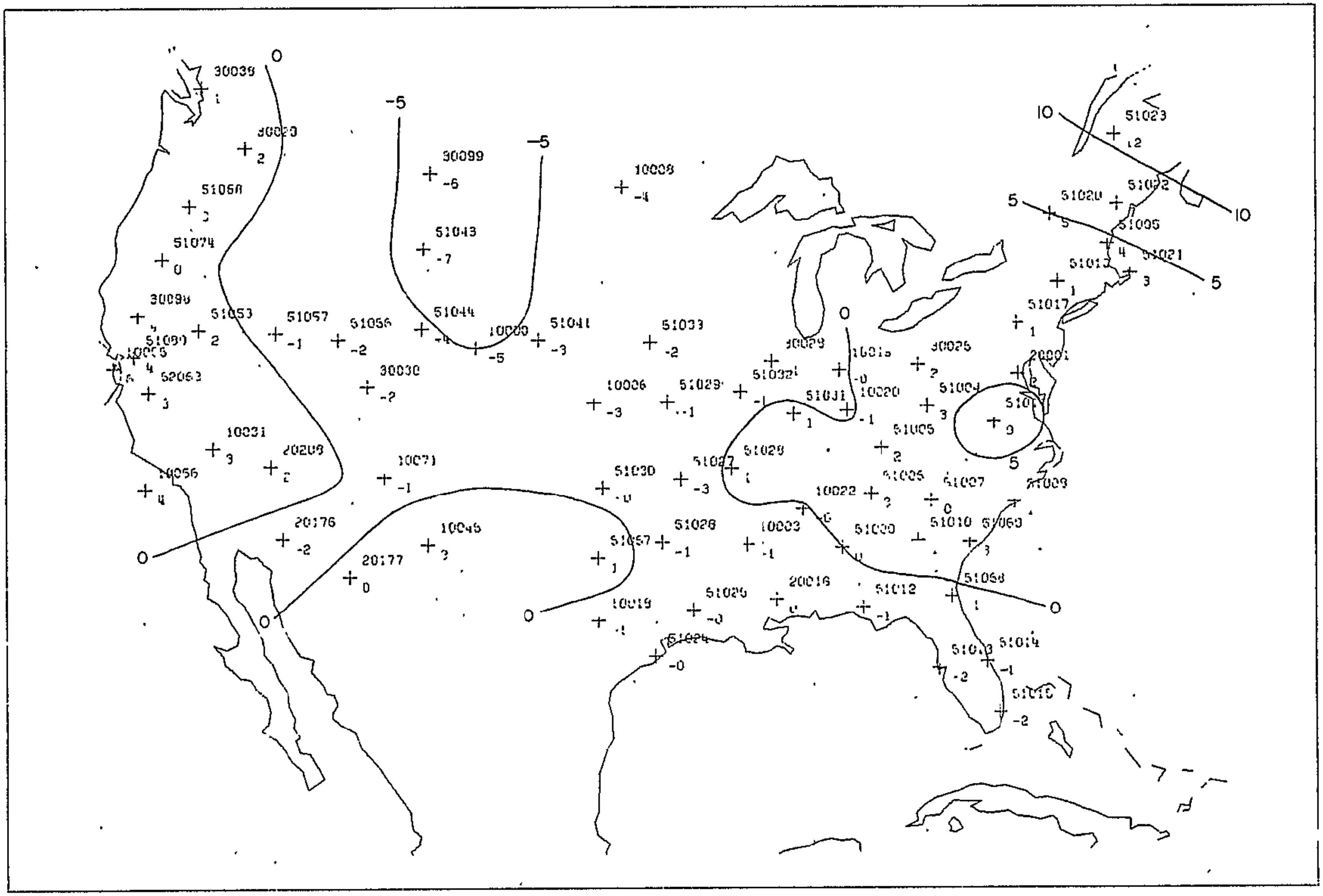


Figure 2.3-5

RESIDUALS

7 Parameter Transformation (NWL9d - NAD): Height

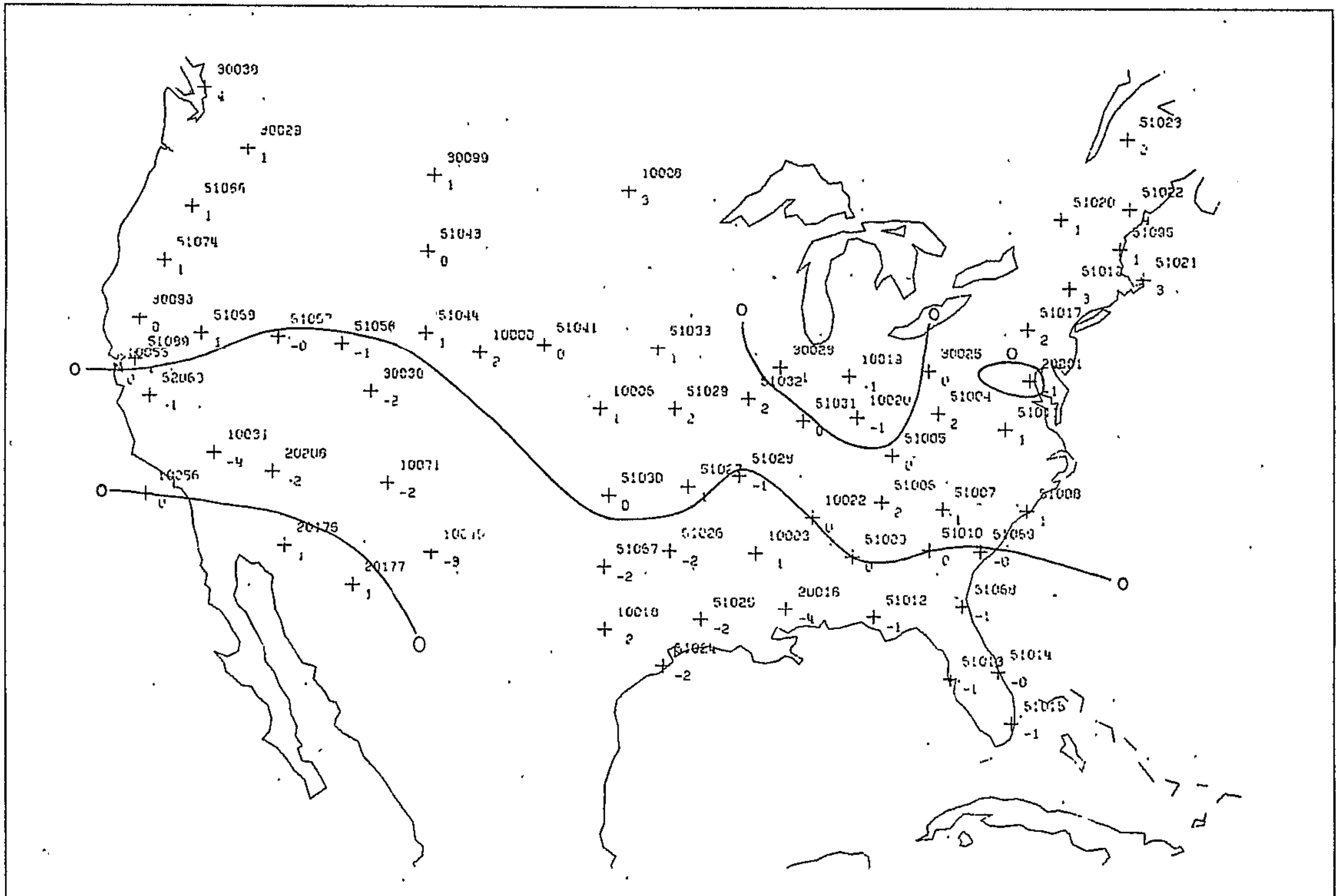


Figure 2.3-6

DEFENSE MAPPING AGENCY
TOPOGRAPHIC CENTER
WASHINGTON, D.C. 20315

REPLY TO
ATTENTION OF:
DMATC-G(52310)

22 OCT 1974

Mr. Alfred Leick
Department of Geodetic Science
1958 Neil Avenue
Columbus, Ohio 43210

Dear Mr. Leick:

Reference is made to your letter dated 30 August 1974 requesting coordinates in the NWL 9D and SAD 69 systems for Doppler stations in Latin America. These data, while not classified, are restricted to the use of the country involved and the United States, and any exception will require the prior approval of the country involved.

We are initiating action to obtain the necessary approvals for the release of the

Sincerely,

Richard T. Peat
for KENNETH I. DAUGHERTY
Chief, Department of Geodesy

301/227-~~2777~~
2212

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

C13

November 7, 1974

Dr. Ivan I. Mueller
Department of Geodetic Science
Ohio State University
Columbus, Ohio 43210

Dear Dr. Mueller:

In accordance with our telephone conversation on this date, data sheets for 76 Doppler stations are enclosed. Data for each station includes Doppler coordinates referred to center of the antenna and geodetic data referred to the marks. In each case, the antenna height is tabulated and the Doppler values can be reduced to the marks. An index of stations by state is also enclosed. Please note my comments in the enclosed copy of my FIG report on page 4.

As discussed, the AFCRL input for IAG is enclosed.

Sincerely,

B. K. Meade

B. K. Meade
Chief, Control Networks Division
National Geodetic Survey

Enclosures

2.32 Determination of Network Distortions for the Australian Geodetic Network (AUS)

The OSU-275 System as Comparison Standard

The OSU-275 system provided a total of 17 stations which could be used for the computations. They included four Doppler stations which were added to the WN14 gometric solution either by direct survey connections or by transformations. Several transformations were performed to delete nearby and double stations and those with unusually large residuals. It was found that the residuals of the Doppler stations did not compare well with the other stations of the WN14. It was, therefore decided to use the Doppler stations independently of the others.

The number of stations thereby was reduced to six stations. The variances as given in the Fourteenth Semiannual Status Report were used in the satellite system. In order to obtain the variance of unit weight close to unity, the variances of the geodetic coordinates had to be scaled to 2.0 m^2 in each axis. The residual maps for the three and seven parameter (Molodensky model) transformations can be found in Figures 2.3-7 through 2.3-12.

The NWL-9D System as Comparison Standard

Mr. A. G. Bomford provided the coordinates of nine Doppler stations which are given in Tables 2.3-7 and 2.3-8. Station 2744, THURSDAY, showed large residuals and station 2726, MANUS IS, was not used since it is too far away from the Australian continent. Again, a three and seven parameter (Molodensky) transformation was performed with respective variances 25.0 m^2 and 2.0 m^2 for the Doppler system and the geodetic system in each coordinate. The distortion maps are shown in Figures 2.3-13 through 2.3-18.

Table 2.3-7

Coordinates in NWL-9D System for Australia

		φ	λ	h(m)
2112	SMITHFIELD	− 34° 40′ 26.″26	138° 39′ 16.″47	15.2
2707	DARWIN	− 12 27 13.02	130 48 55.43	52.2
2709	MUCHEA	− 31 36 25.47	115 55 52.45	44.0
2725	TOWNSVILLE	− 19 15 24.64	146 42 58.89	47.4
2726	MANUS IS	− 2 03 02.59	147 21 37.37	124.0
2743	WOOMERA	− 31 23 25.49	136 52 41.88	127.0
2744	THURSDAY	− 10 35 00.64	142 12 39.90	137.1
2749	TIDBINBILLA	− 35 24 12.88	148 58 56.16	644.2
2805	CULGOORA	− 30 18 34.13	149 33 40.30	223.9

Table 2.3-8

Coordinates in Australian Geodetic Datum

a = 6378160 m, // f = 298.25

		φ	λ	h(m)
2112	SMITHFIELD	− 34° 40′ 31.″43	138° 39′ 12.″38	36.6
2707	DARWIN	− 12 27 17.89	130 48 51.95	25.7
2709	MUCHEA	− 31 36 29.51	115 55 47.61	93.8
2725	TOWNSVILLE	− 19 15 30.01	146 42 55.62	14.5
2726	MANUS IS	− 2 03 7.12	147 21 34.46	53.1
2743	WOOMERA	− 31 23 30.61	136 52 37.89	142.0
2744	THURSDAY	− 10 35 6.15	142 12 37.06	61.3
2749	TIDBINBILLA	− 35 24 18.36	148 58 52.75	654.3
2805	CULGOORA	− 30 18 39.61	149 33 36.72	215.9

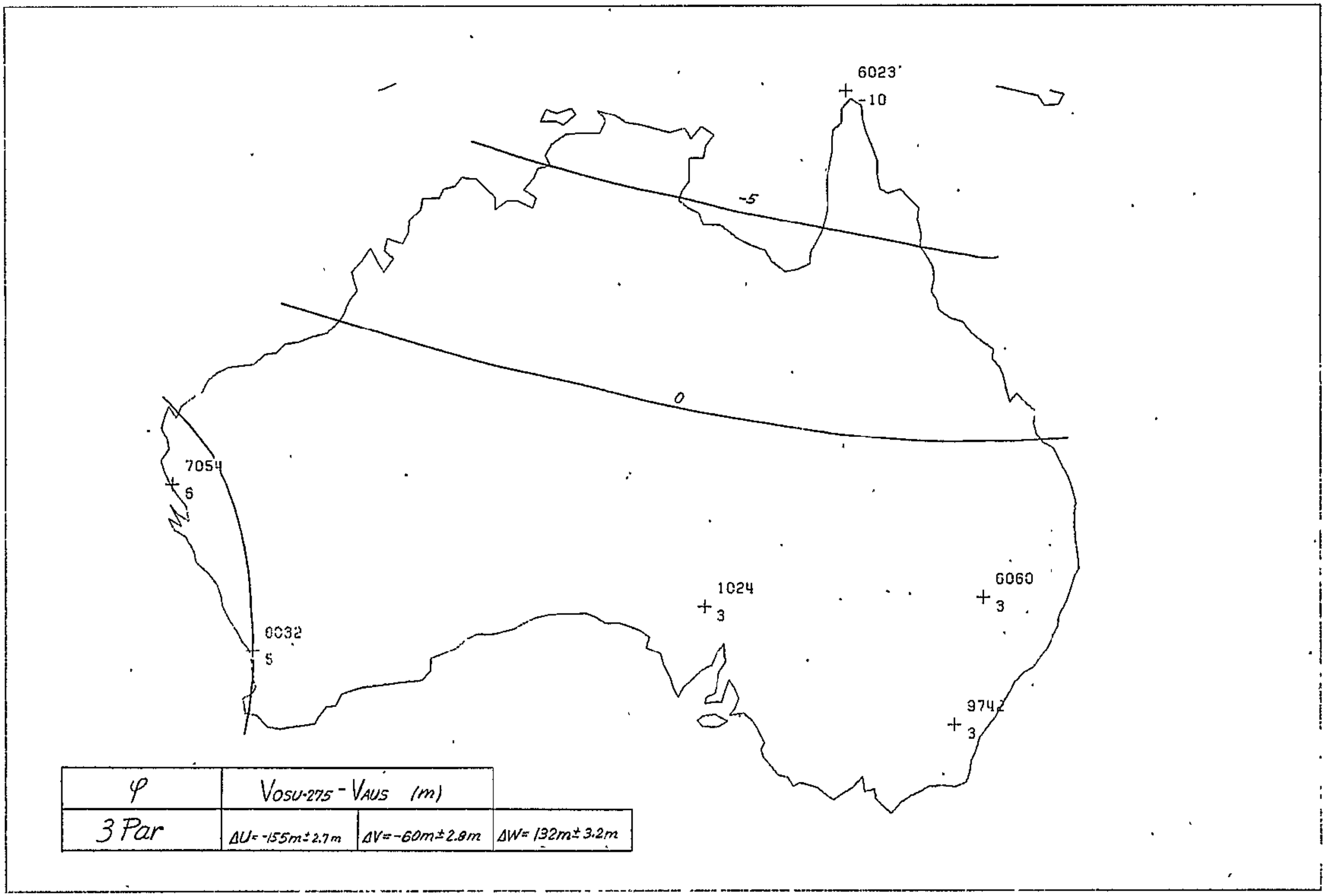

6023
-10
-5
0
7054
6
6032
5
1024
3
6060
3
9742
3
φ
$V_{OSU-275} - V_{AUS}$ (m)
3 Par
ΔU= -155m ± 2.7m
ΔV= -60m ± 2.8m
ΔW= 132m ± 3.2m

Figure 2.3-7

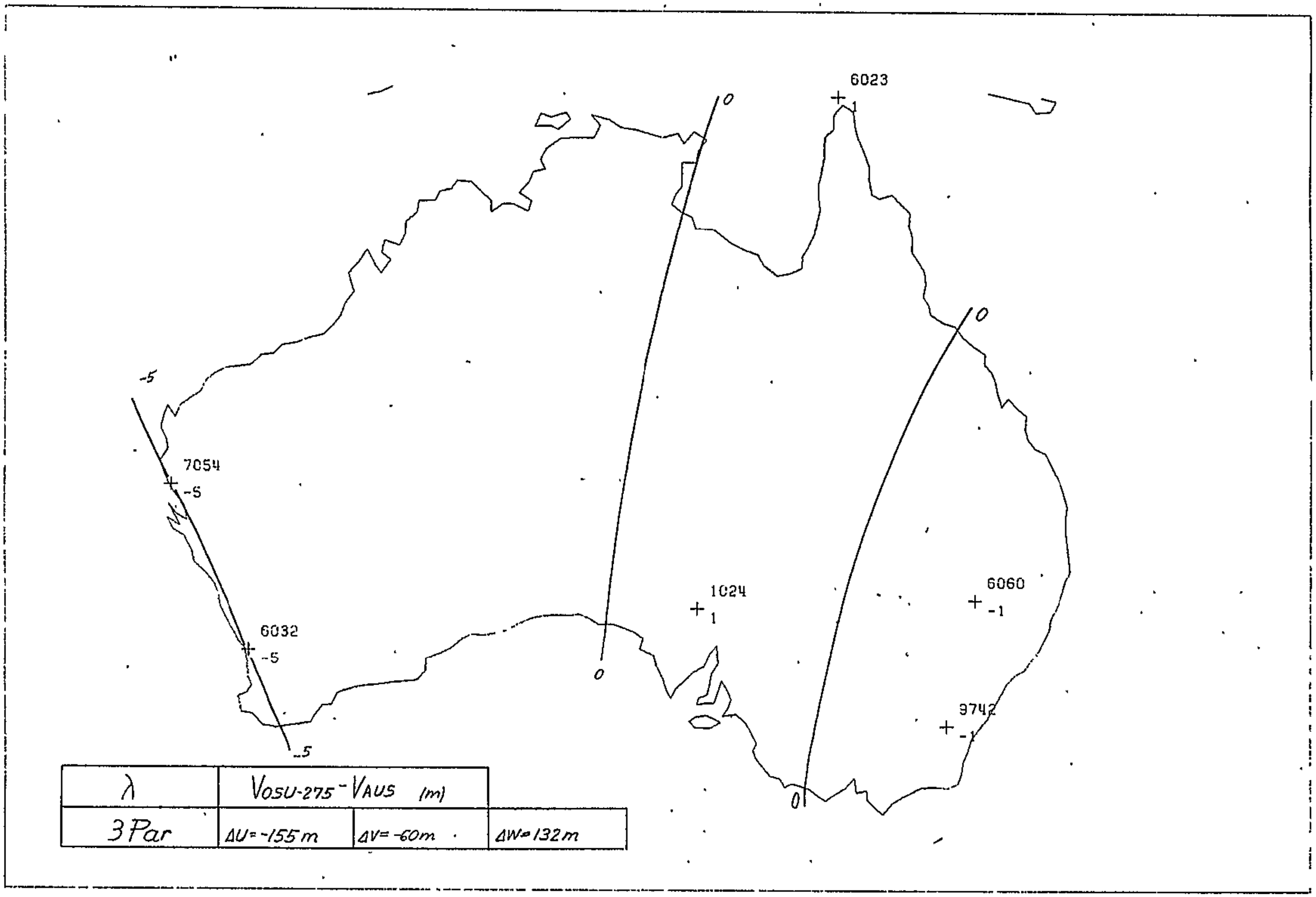

6023
1
0
0
-5
7054
-5
6032
-5
-5
0
1024
1
6060
-1
9742
-1
0
λ
VOSU-275 - VAUS (m)
3Par
ΔU=-155m
ΔV=-60m
ΔW=132m

Figure 2.3-8

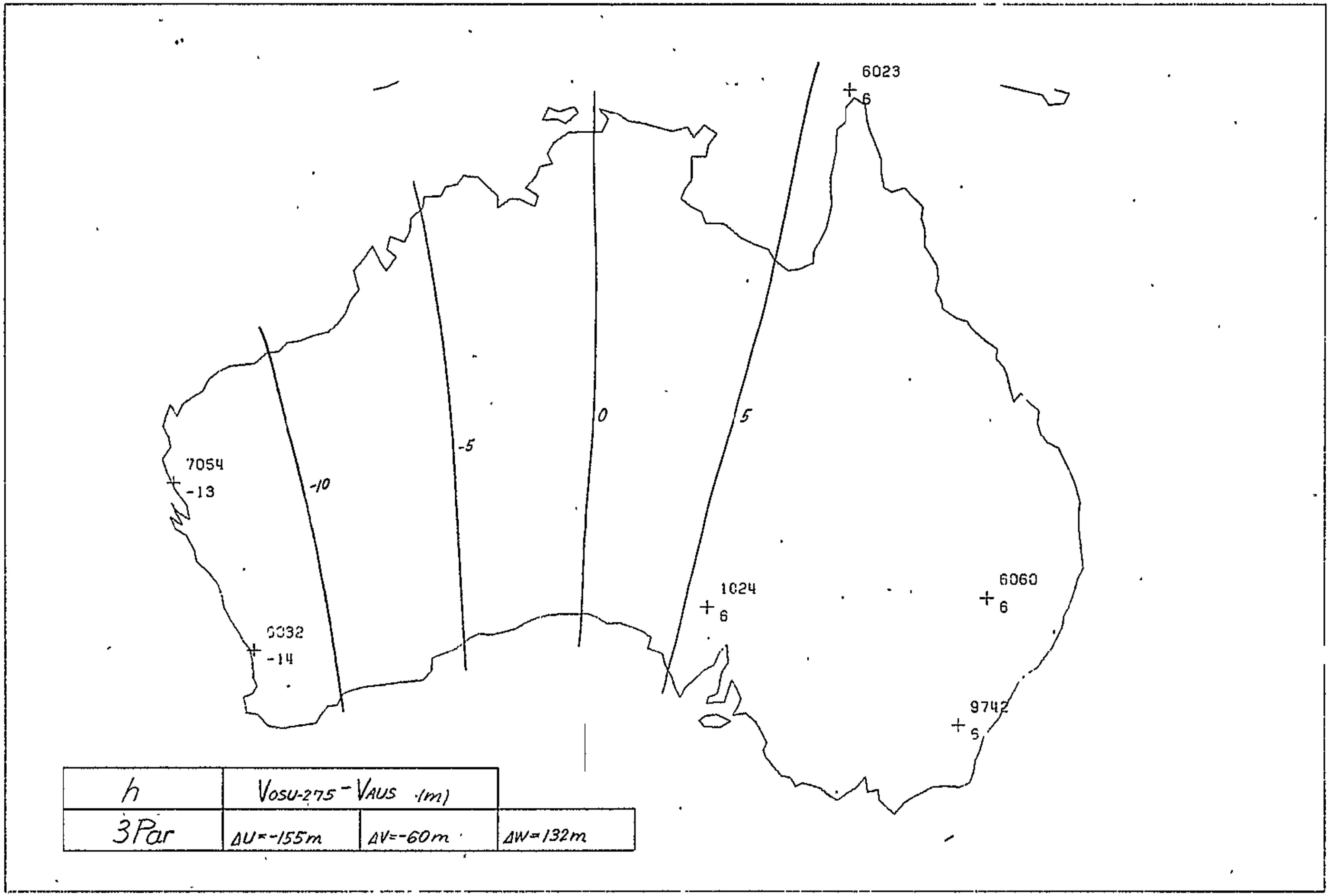

6023
6
7054
-13
6032
-14
1024
6
6060
6
9742
5
-10
-5
0
5
h
Vosu-275 - VAUS (m)
3Par
ΔU=-155m
ΔV=-60m
ΔW=132m

Figure 2.3-9

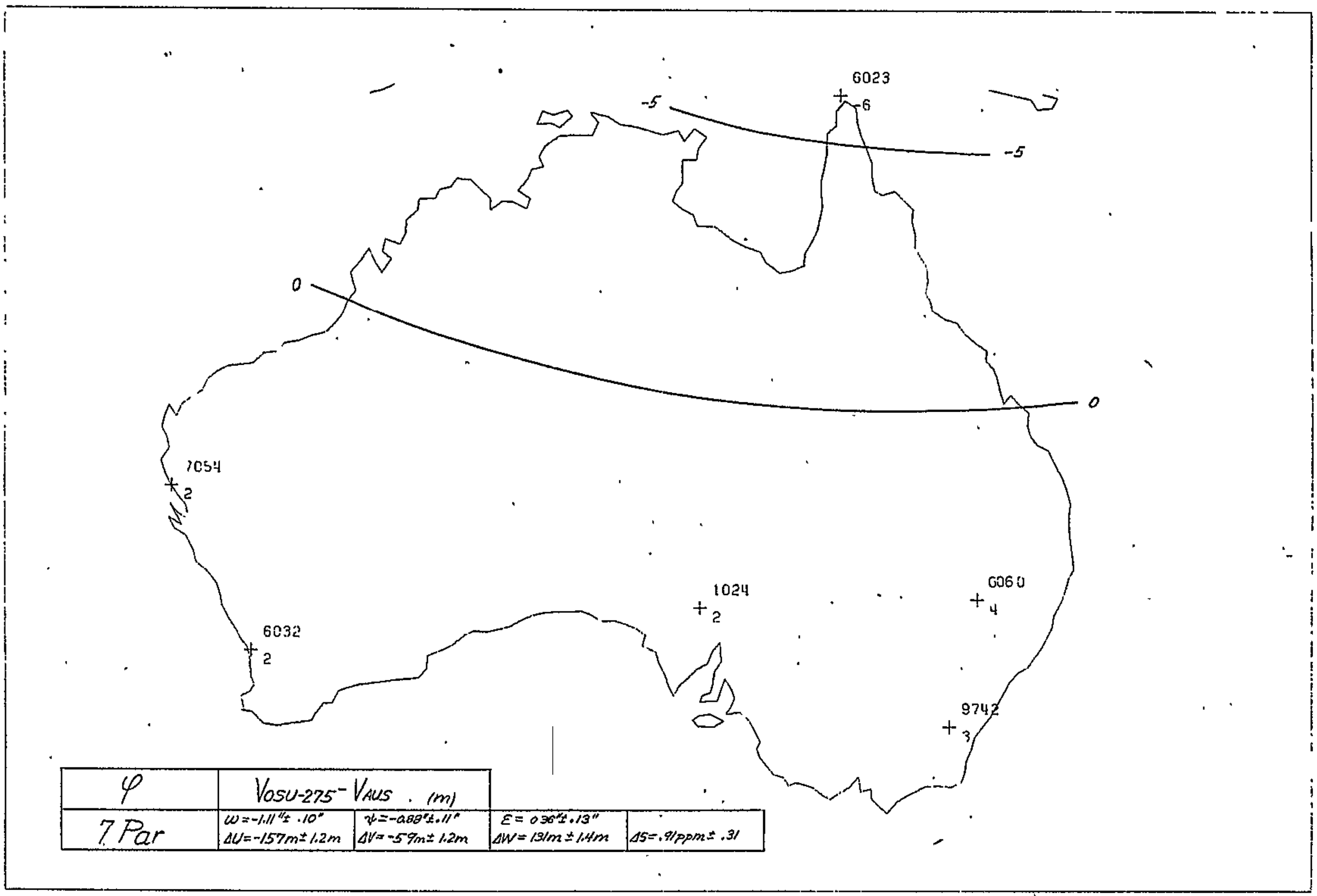
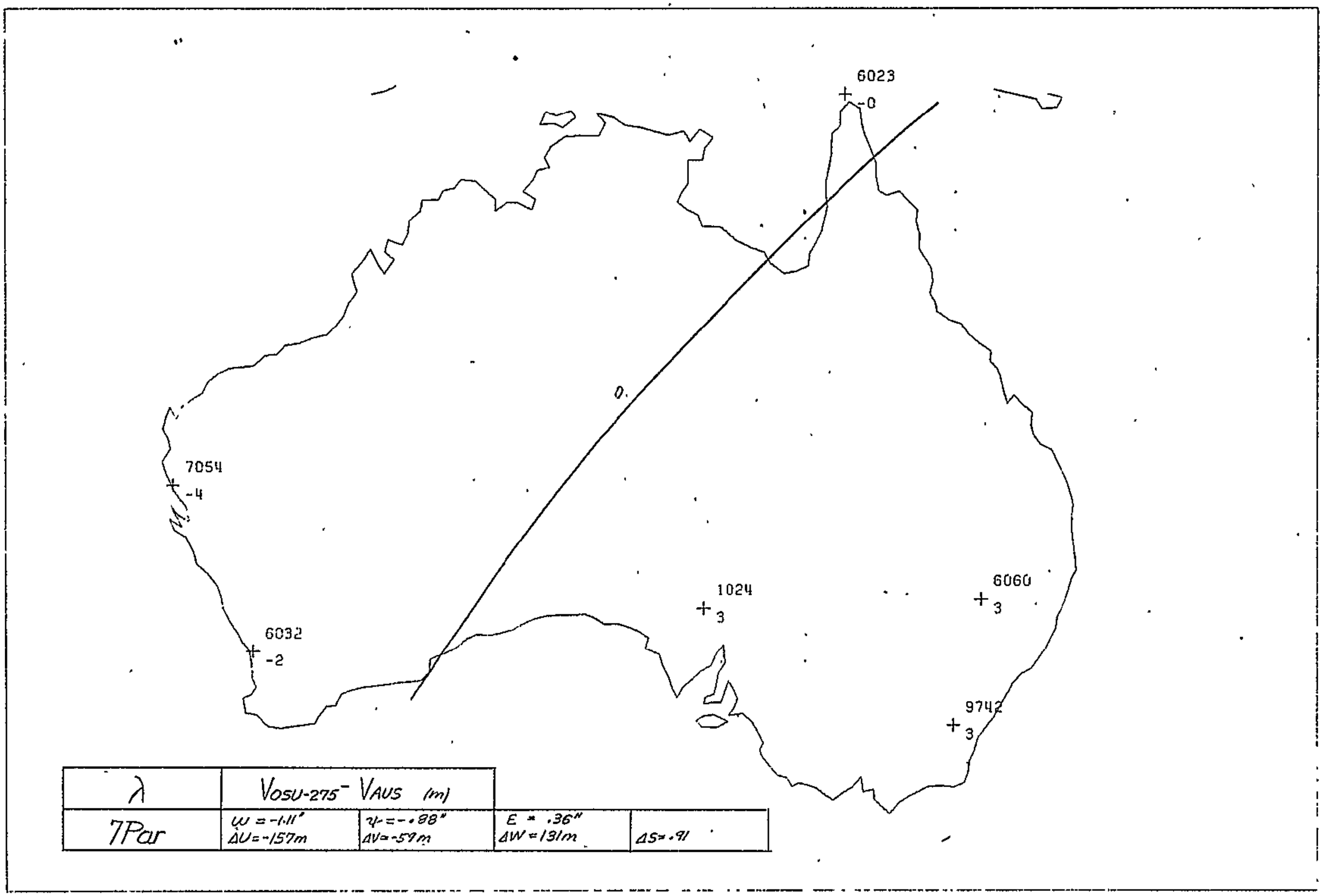
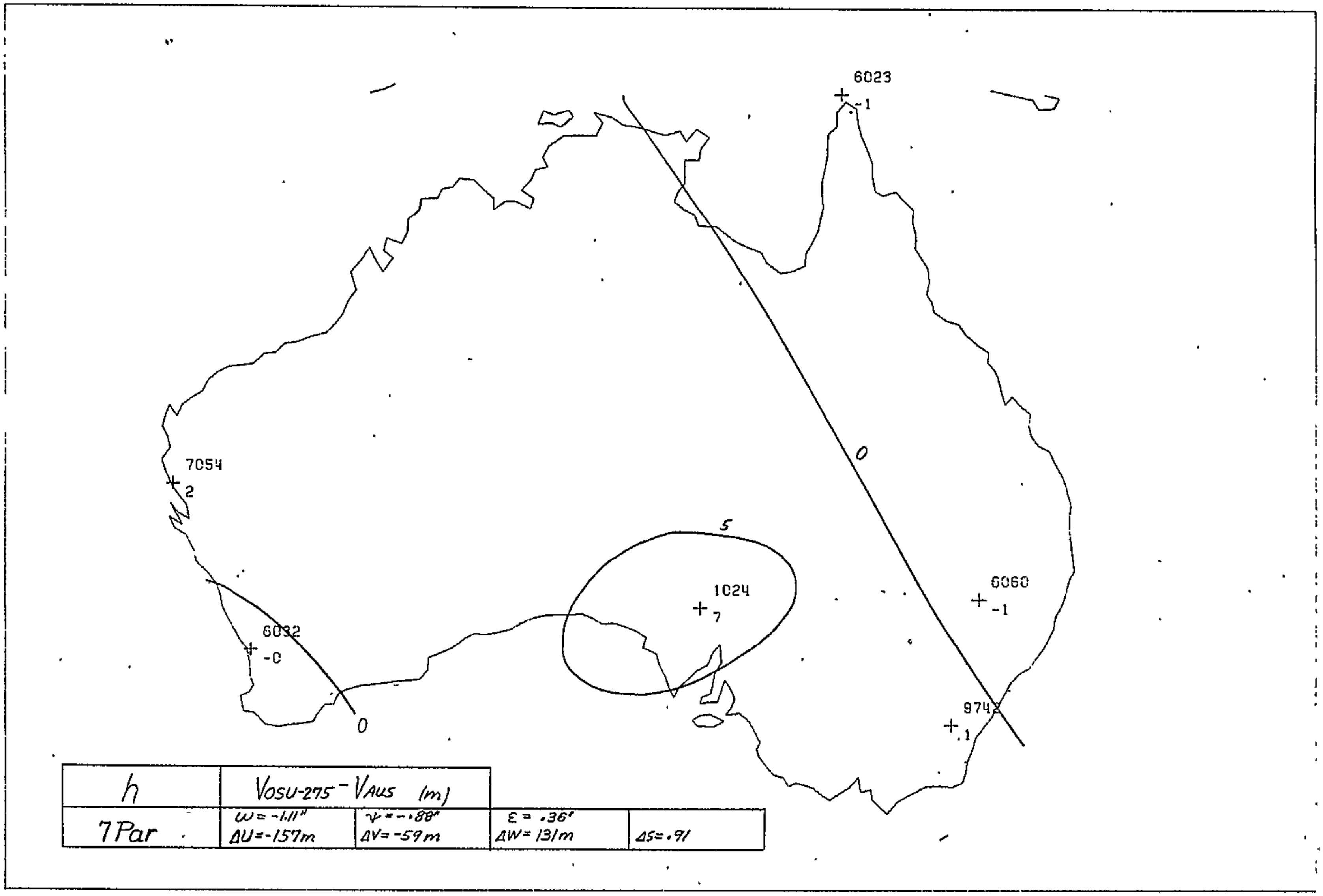

6023
-5
-6
-5
0
0
7054
2
1024
2
6060
4
6032
2
9742
3
φ
VOSU-275 - VAUS . (m)
7 Par
ω=-1.11"± .10"
ΔU=-157m± 1.2m
ψ=-0.88"±.11"
ΔV=-59m± 1.2m
ε= 0 36"±.13"
ΔW= 131m ± 1.4m
ΔS=.91ppm± .31

Figure 2.3-10



λ	$V_{OSU-275} - V_{AUS}$ (m)			
7Par	$\omega = -1.11''$ $\Delta U = -157m$	$\psi = -.88''$ $\Delta V = -59m$	$\varepsilon = .36''$ $\Delta W = 131m$	$\Delta S = .91$

Figure 2.3-11



6023
-1
7054
2
6032
-0
0
5
1024
7
6060
-1
.1
0
h
VOSU-275 - VAUS (m)
7Par
ω = -1.11"
ΔU = -157m
ψ = -.88"
ΔV = -59m
ε = .36"
ΔW = 131m
ΔS = .91

Figure 2.3-12

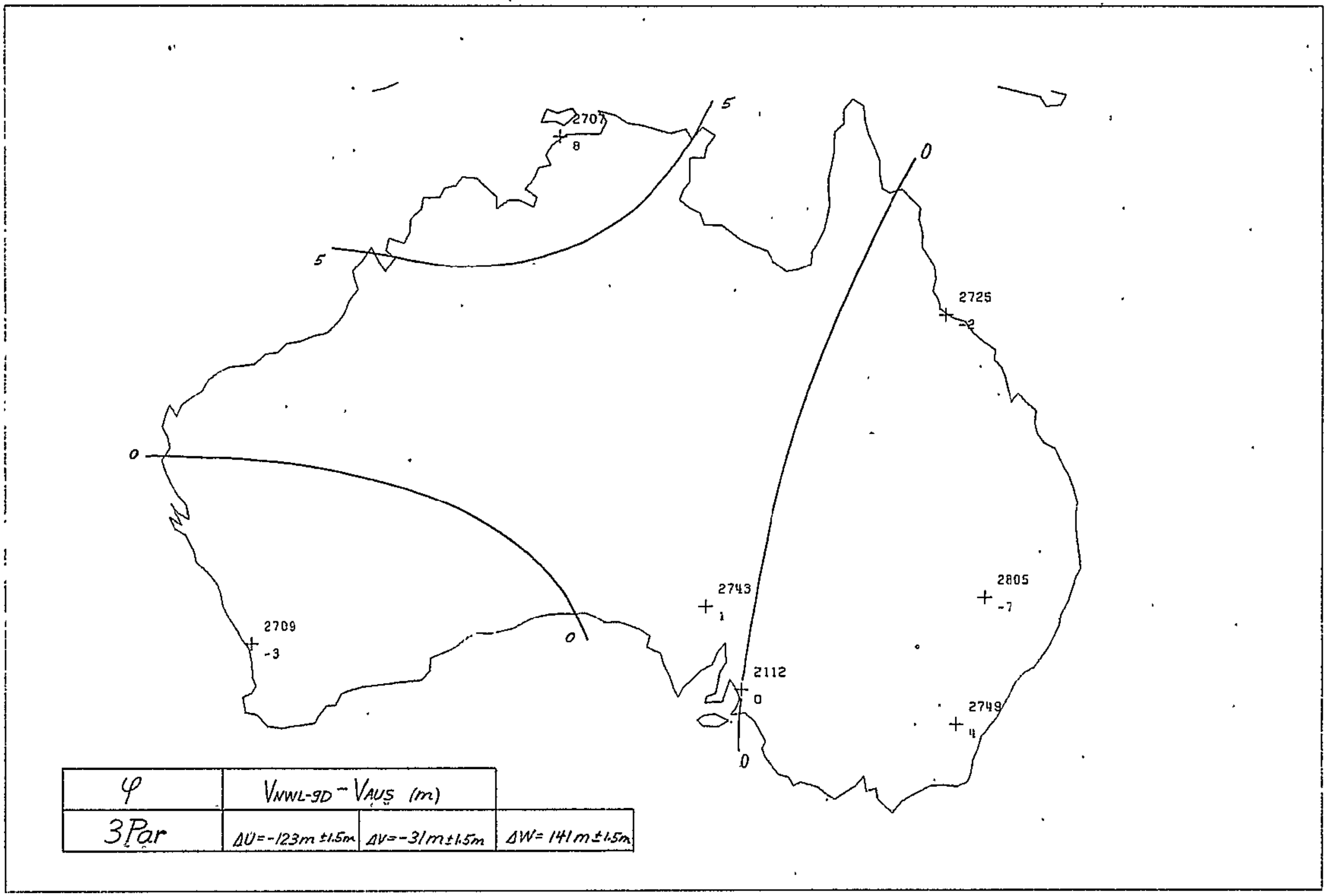
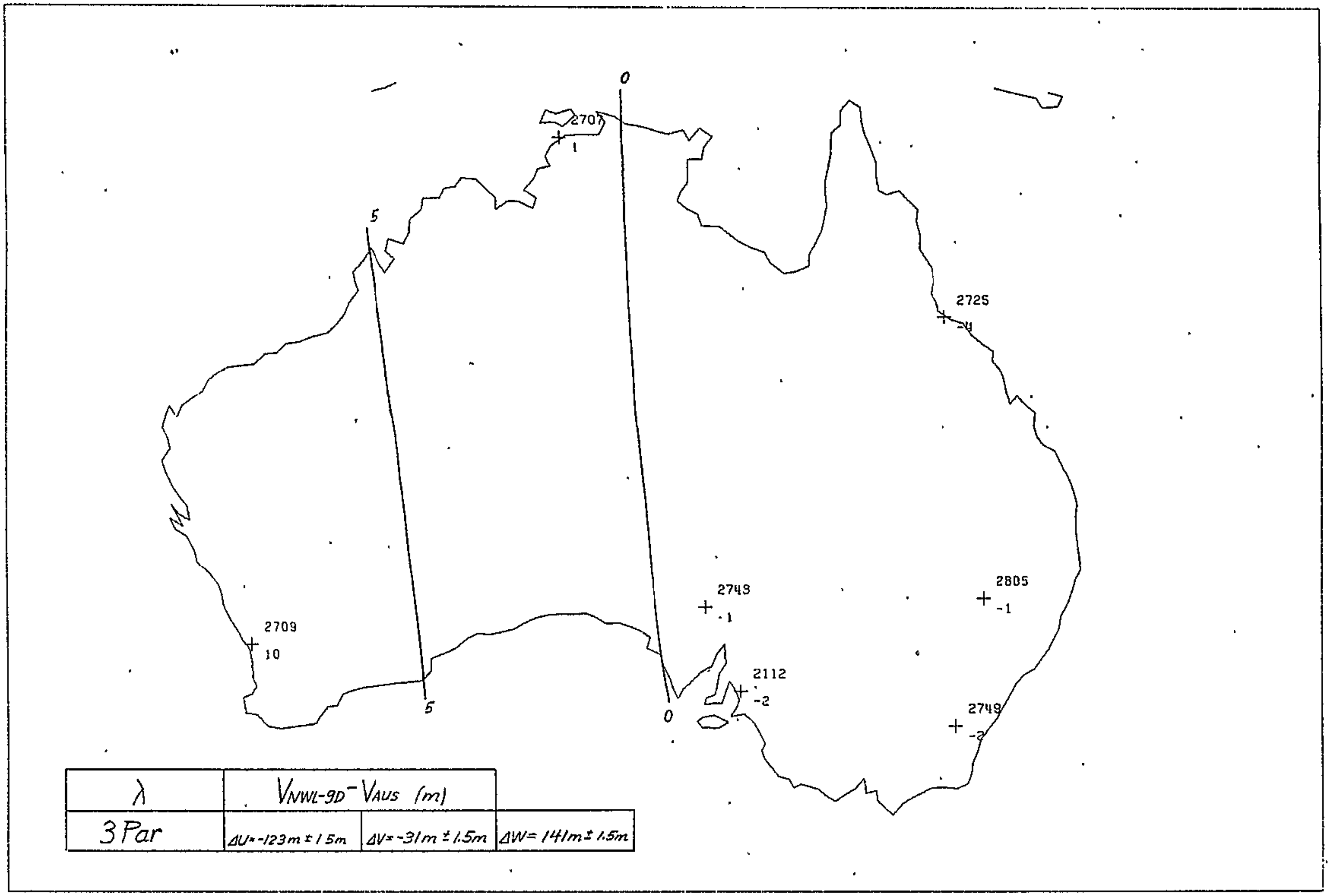

5
5
0
0
0
0
2707
8
2725
-2
2743
1
2805
-7
2709
-3
2112
0
2749
4
φ
VNWL-9D - VAUS (m)
3Par
ΔU=-123m ±1.5m
ΔV=-31m±1.5m
ΔW=141m±1.5m

Figure 2.3-13



λ	$V_{NWL-9D} - V_{AUS}$ (m)		
3 Par	ΔU=-123m ± 1.5m	ΔV=-31m ± 1.5m	ΔW= 141m ± 1.5m

Figure 2.3-14

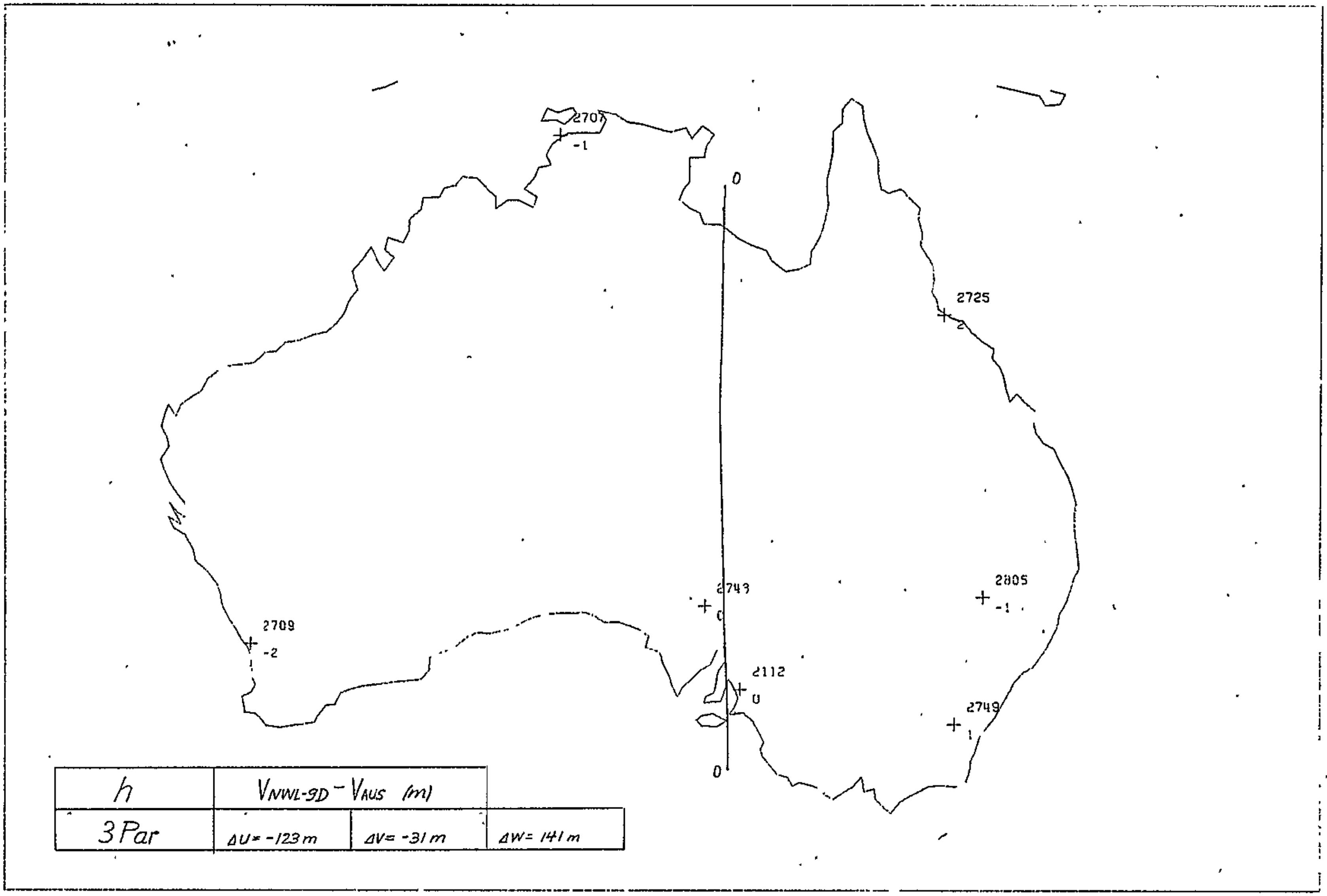

2707
-1
2725
2
2709
-2
2743
0
2112
0
2805
-1
2749
1
0
0
h
$V_{NWL-9D} - V_{AUS}$ (m)
3 Par
ΔU= -123 m
ΔV= -31 m
ΔW= 141 m

Figure 2.3-15

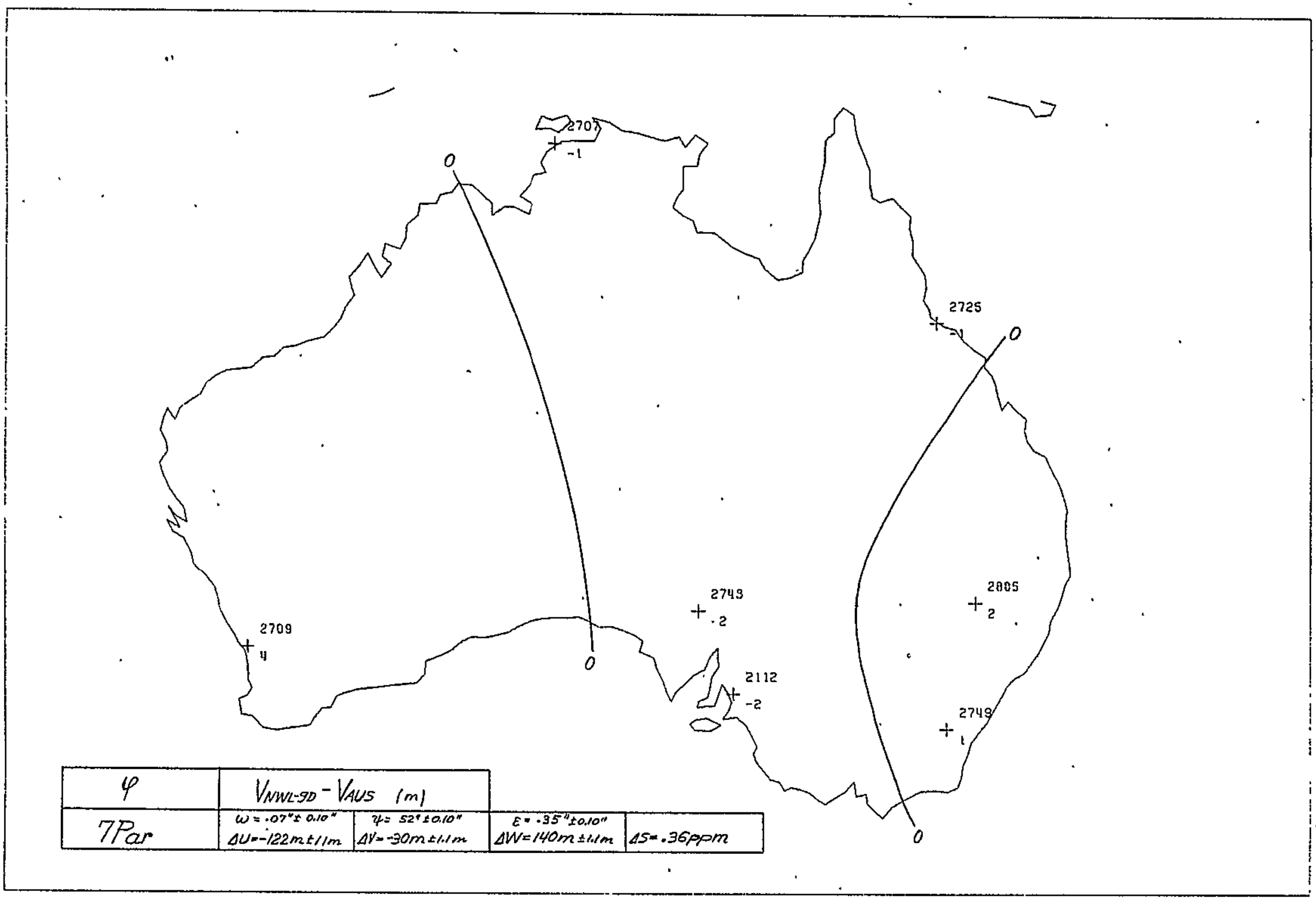

2707
-1
2725
-1
2743
.2
2805
2
2709
4
2112
-2
2749
1
0
0
0
0
φ
V NWL-9D - V AUS (m)
7Par
ω = .07" ± 0.10"
ΔU = -122m ± 1.1m
ψ = .52" ± 0.10"
ΔV = -30m ± 1.1m
ε = .35" ± 0.10"
ΔW = 140m ± 1.1m
ΔS = .36ppm

Figure 2.3-16

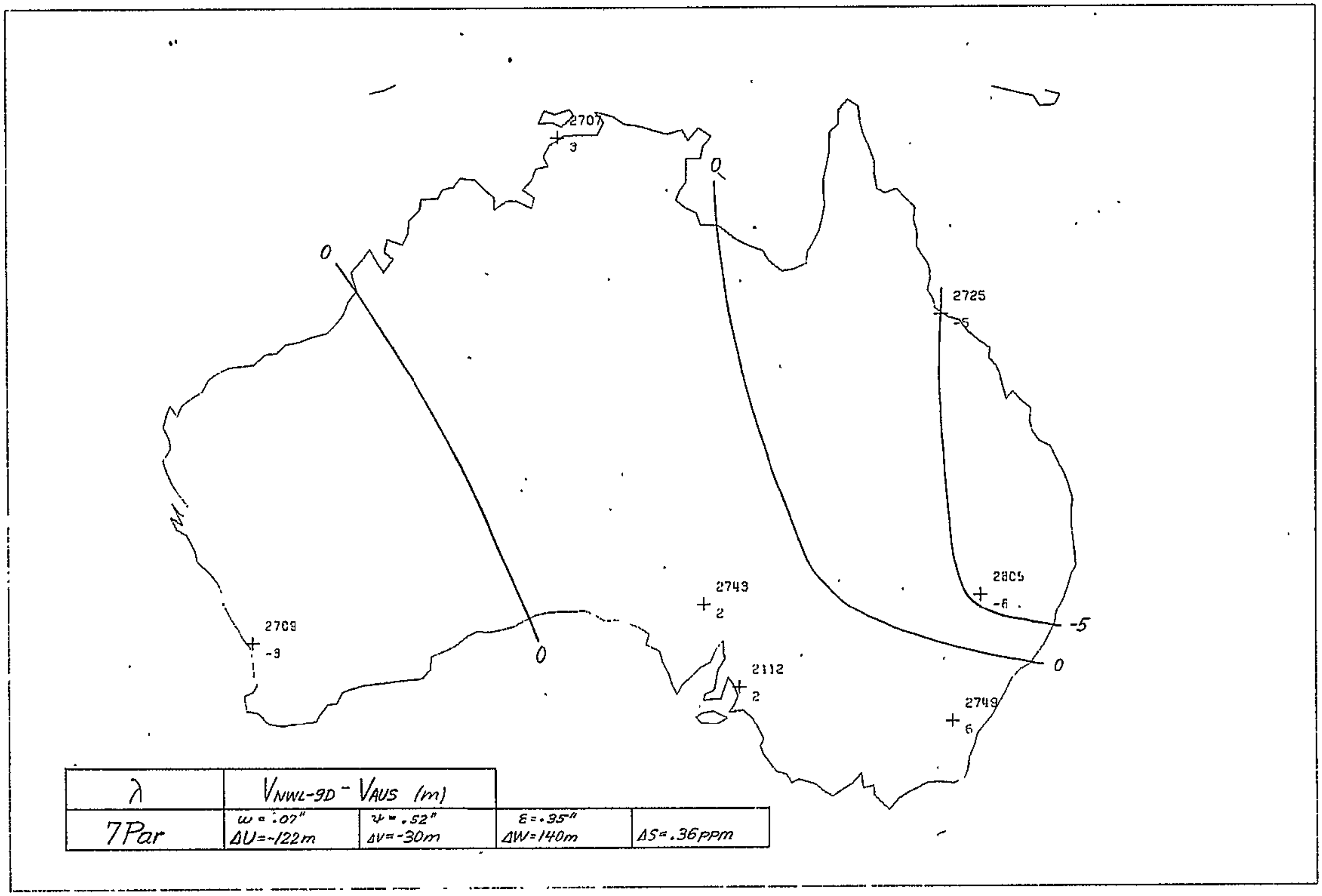

2707
3
2725
-5
2805
-6
2743
2
2709
-9
2112
2
2749
6
0
0
0
-5
0
λ
V_NWL-9D - V_AUS (m)
7Par
ω = .07"
ΔU=-122m
ψ = .52"
ΔV=-30m
ε = .35"
ΔW=140m
ΔS=.36ppm

Figure 2.3-17

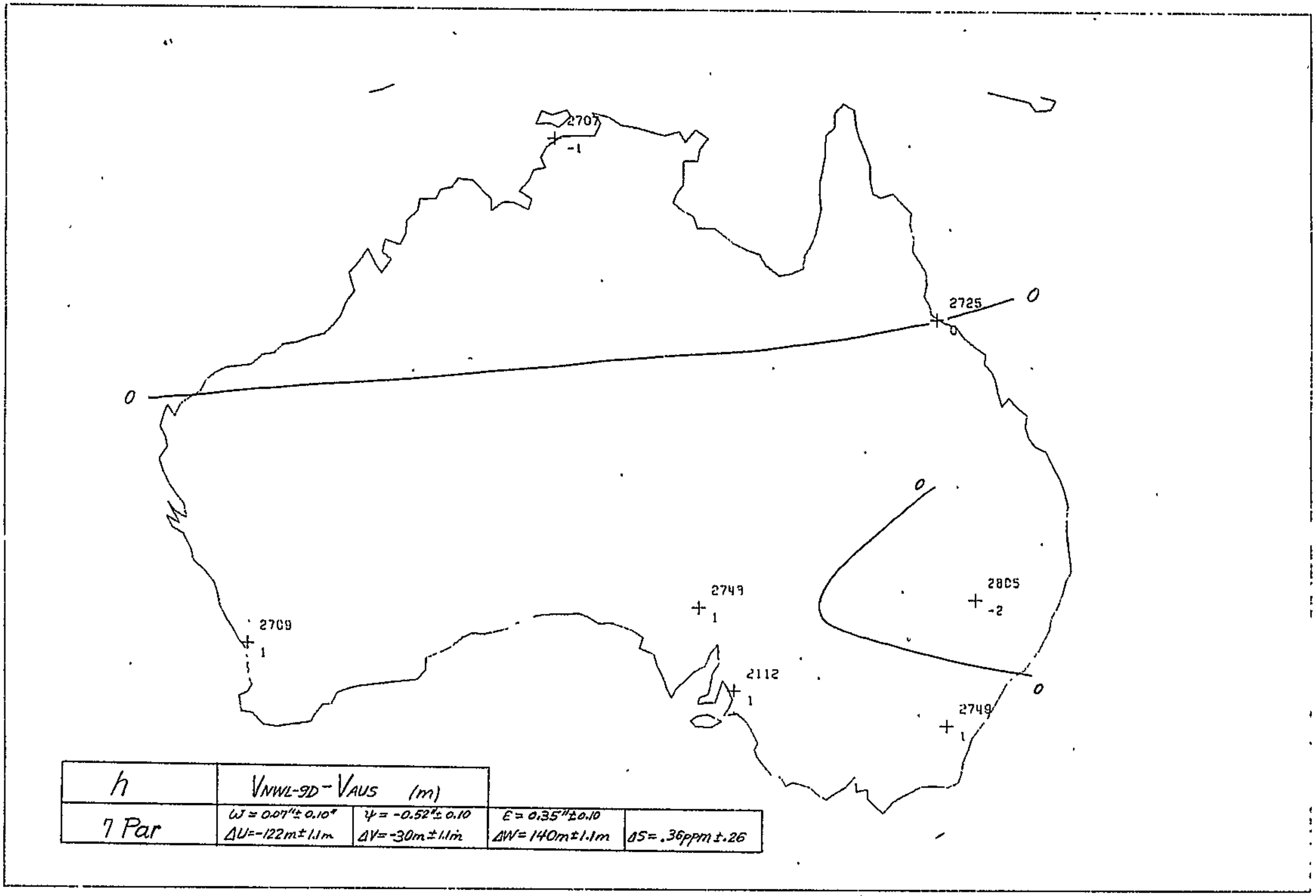

2707
-1
2725
0
0
0
0
0
2709
1
2749
1
2112
1
2805
-2
2749
1
h
$V_{NWL-9D} - V_{AUS}$ (m)
7 Par
$\omega = 0.07'' \pm 0.10''$
$\Delta U = -122m \pm 1.1m$
$\psi = -0.52'' \pm 0.10$
$\Delta V = -30m \pm 1.1m$
$\varepsilon = 0.35'' \pm 0.10$
$\Delta W = 140m \pm 1.1m$
$\Delta S = .36ppm \pm .26$

Figure 2.3-18

3. ACTIVITIES RELATED TO EOPAP
(Grant No. NGR 36-008-204)

3.1 Sea Level Slopes Along the Continental Boudaries of the U.S.A.

3.11 Introduction

Geodesists and oceanographers have disagreed on the direction and magnitude of the North-South sea level slopes along the East and West Coasts of the United States.

There was some room to doubt the validity of the comparisons between the results of the geodesists and the oceanographers since they use different methods and different reference surfaces for the determination of these slopes.

An attempt has now been made to compare the results of the oceanographers and geodesists by reducing them to the same terms.

3.12 Method of Calculation

The results of both geodetic and oceanic leveling have been reduced to the following compatible quantities for comparison at several stations along the two coasts:

(i) Geopotential difference between the sea level and the deep sea isobaric surface used as a reference surface in oceanic leveling;

(ii) Orthometric height between the sea level and the same deep sea isobaric surface.

Values at the various stations for the (anamolous) dynamic heights of the sea level with respect to the deep sea isobaric surface of reference have been taken from the graphs of Wilton Sturges [4]. Values at these stations for the geometric height differences between the sea level and the reference geopotential surface used in geodetic leveling have been taken from the graphs of Emery Balazs [1].

The standard geopotential difference between the 0-db surface (sea level) and the 1000-db surface has been taken as 9704.032 $m^2\ s^{-2}$ [3]. The standard geopotential difference between the 0-db surface and the 2000-db surface has

been taken as 19364.200 $m^2 s^{-2}$ [2].

Computations have been carried out for 21 stations along the East Coast (West Atlantic) and for 8 stations along the West Coast (East Pacific). The following assumptions have been made:

(i) The deep sea isobaric surface used as a reference in oceanic leveling is an equipotential surface;

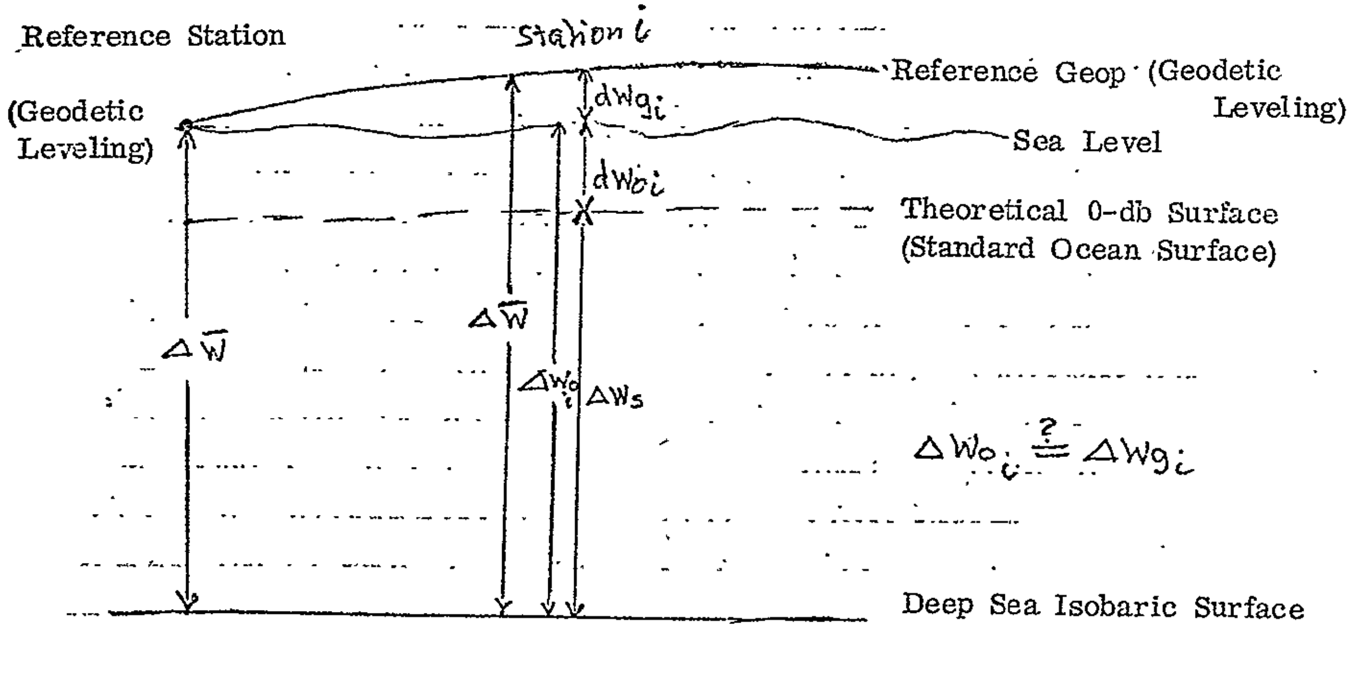
(ii) Oceanic and geodetic leveling is in perfect agreement at Neah Bay on the West Coast and Port Maine on the East Coast, both sea levels having been used as references in geodetic leveling along the West and East Coasts respectively;

(iii) The gravity field of the earth is well described by normal gravity field in the areas under investigation and gravity varies linearly with height/depth up to 2 kilometers.

3.121 Calculation of Geopotential Difference

A. Oceanic Leveling

Figure 3.1-1



$$\Delta W_{0_i} = \Delta W_s + dW_{0_i} = g_{m_i} (H_s + h_{D_i}) \tag{1}$$

where

ΔW_{0_i} is the geopotential difference between the deep sea isobaric surface and the sea level at station i, as per oceanic leveling;

ΔW_s is the standard geopotential difference between the deep sea isobaric surface and the sea level (0-db surface). The value for this is 9707.032 $m^2 s^{-2}$ for 1000-db surface (used as a reference on West Coast) and 19364.200 $m^2 s^{-2}$ for 2000-db surface (used as reference on East Coast);

dW_{0_i} is the anomalous geopotential difference at station i;

h_{D_i} is the dynamic height at the computation station as per graphs of W. Sturges and is interpreted as per Equation (1) above;

g_{m_i} is the mean normal gravity between the sea level and the deep sea isobaric surface, at the computation station in gals;

H_s is the orthometric height corresponding to the standard geopotential difference ΔW_s ;

therefore, $dW_{0_i} = h_D \times g_{m_i}$, since $\Delta W_s = g_{m_i} \times H_s$. (2)

Based on the geodetic reference system 1967:

$$\begin{aligned} g_{m_i} = 978.03185 \, (1 &+ 0.005278895 \sin^2 \varphi_i \\ &+ 0.000023462 \sin^4 \varphi_i \\ &- 0.0000003155 \frac{H_i}{2}) \end{aligned} \tag{3}$$,

where

φ_i is the latitude at the computation station; and

H_i is the orthometric height between the deep sea isobaric surface and the sea level at the computation station (in meters).

0.0000003155 H represents the free air altitude effect on gravity.

Also,

$$\Delta W_{0_i} = g_{m_i} \times H_i . \tag{4}$$

g_{s_i} and H_i are determined such that Equations (2), (3) and (4) are satisfied. Initial value of H_i has been taken as -1000 meters for the West Coast and -2000 meters for the East Coast.

B. Geodetic Leveling

$$\Delta W_{g_i} = \Delta \overline{W} - dW_{g_i} \tag{5}$$

where

ΔW_{g_i} is the geopotential difference between the deep sea isobaric surface and the sea level at a station i, as per geodetic leveling;

$\Delta \overline{W}$ is the geopotential difference between the deep sea isobaric surface and the sea level at the station used as reference in geodetic leveling (reference geop), computed as given in section A; and

dW_{g_i} is the difference of geopotential between the reference geop of geodetic leveling and the sea level at the computation station.

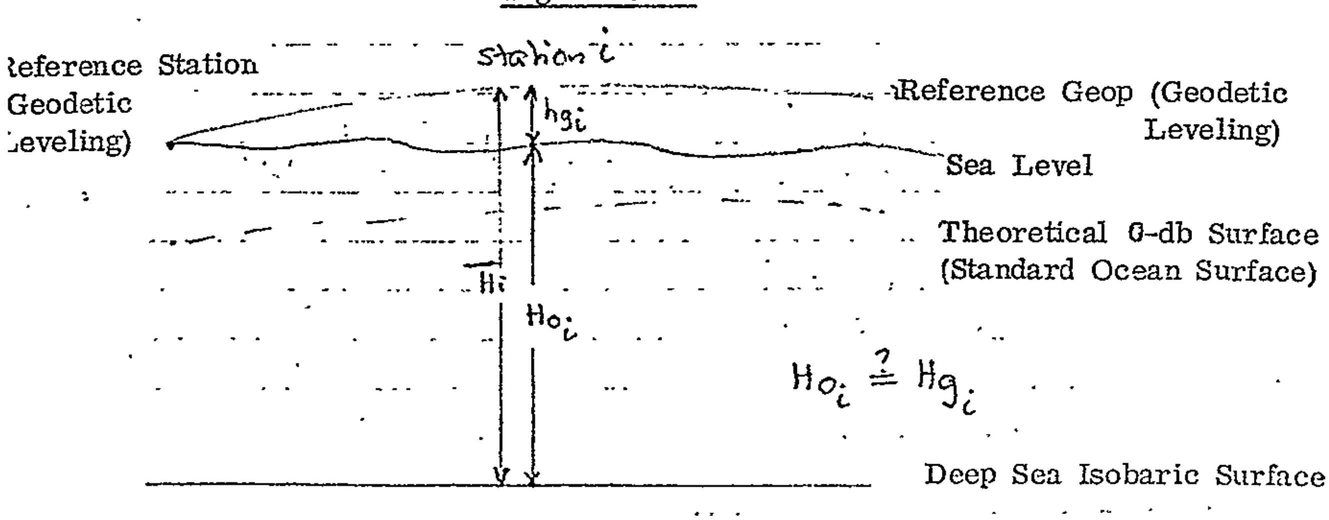
$$dW_{g_i} \cong h_{g_i} \times g_{s_i} , \tag{6}$$

where

h_{g_i} is the geometric height difference at the computation station (between the reference geop and the sea level), obtained from the graphs of E. Balazs;

g_{s_i} is the gravity at sea level obtained by inserting H = 0 in Equation (3).

Figure 3.1-2



3.122 Calculation of Orthometric Height Differences

A. Oceanic Leveling

H_{0_i}, the orthometric height between the sea level and the deep sea isobaric surface at a station i, as per oceanic leveling, will be identical to H_i computed in section 3.121/A.

B. Geodetic Leveling

If $\overline{H}_i$ is the orthometric height at station i between the deep sea isobaric surface and the reference geop of geodetic leveling (corresponding to the geopotential difference $\Delta\overline{W}$), computed as per section 3.121/B, then

$$H_{g_i} = \overline{H}_i - h_{g_i} \qquad (7)$$

Where

H_{g_i} is the orthometric height between the sea level and the deep sea isobaric surface at station i, as per geodetic leveling.

3.123 Comparison of Results

ΔW_{0_i} and ΔW_{g_i} have been computed as per section 3.121, and graphs for $\Delta W_i = \Delta W_{0_i} - \Delta W_{g_i}$ against latitude have been shown in Figures 3.1-4 and 3.1-6 for the East and West Coasts respectively.

H_{0_i} and H_{g_i} have been computed as per section 3.122, and graphs for these quantities against latitude have been shown in Figures 3.1-3 and 3.1-5 for the East and West Coasts respectively.

3.13 Conclusions

(i) The results of oceanic and geodetic leveling are comparable. In terms of magnitude, the discrepancies as pointed out by oceanographers, between oceanographic and geodetic leveling, do exist.

(ii) If the deep sea isobaric surface is taken as the level surface of reference, the results of both oceanic and geodetic leveling indicate that the ocean is sloping down from South to North, along both the East and West Coasts.

East Coast (West Atlantic)

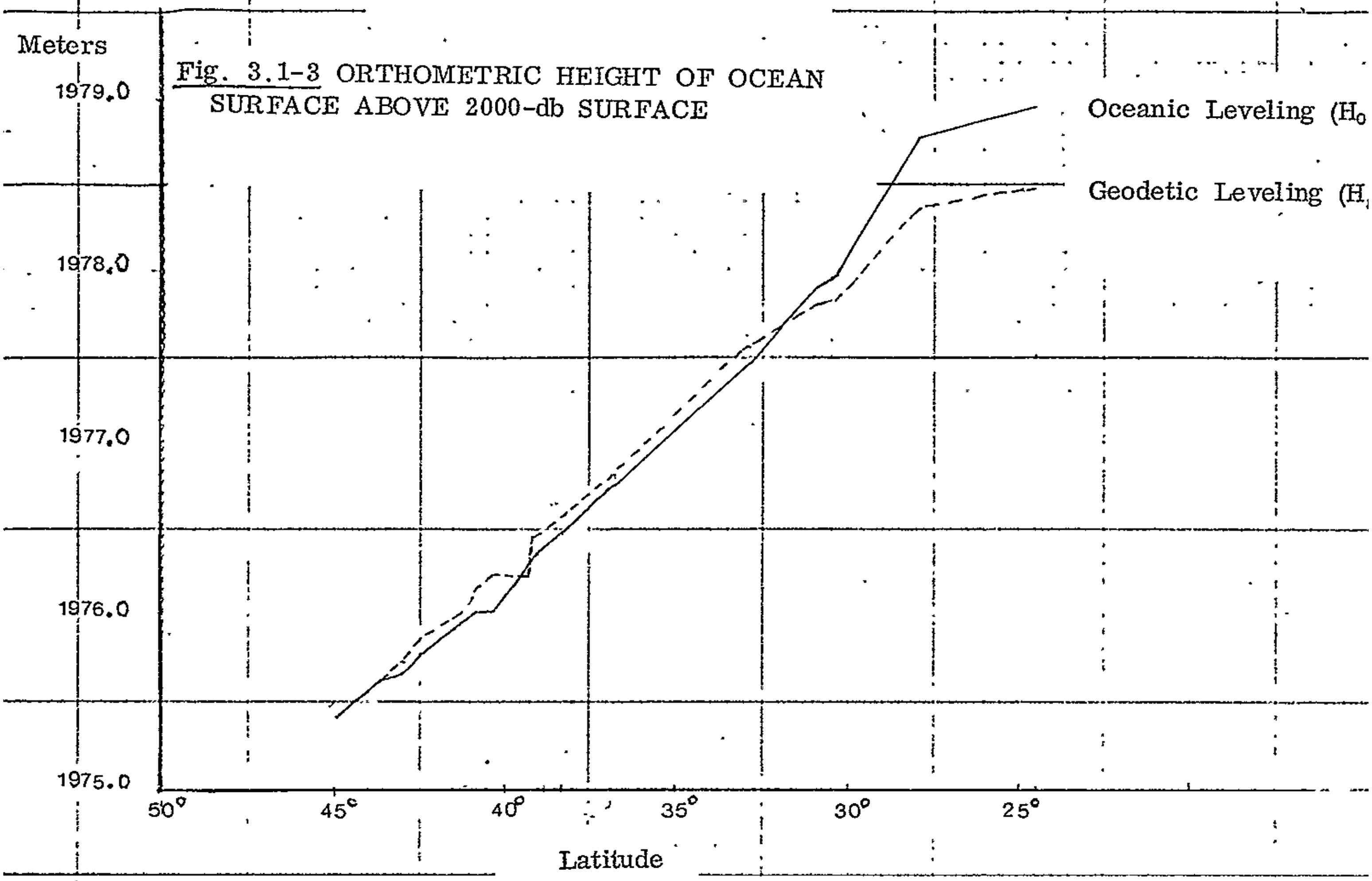


Fig. 3.1-3 ORTHOMETRIC HEIGHT OF OCEAN SURFACE ABOVE 2000-db SURFACE

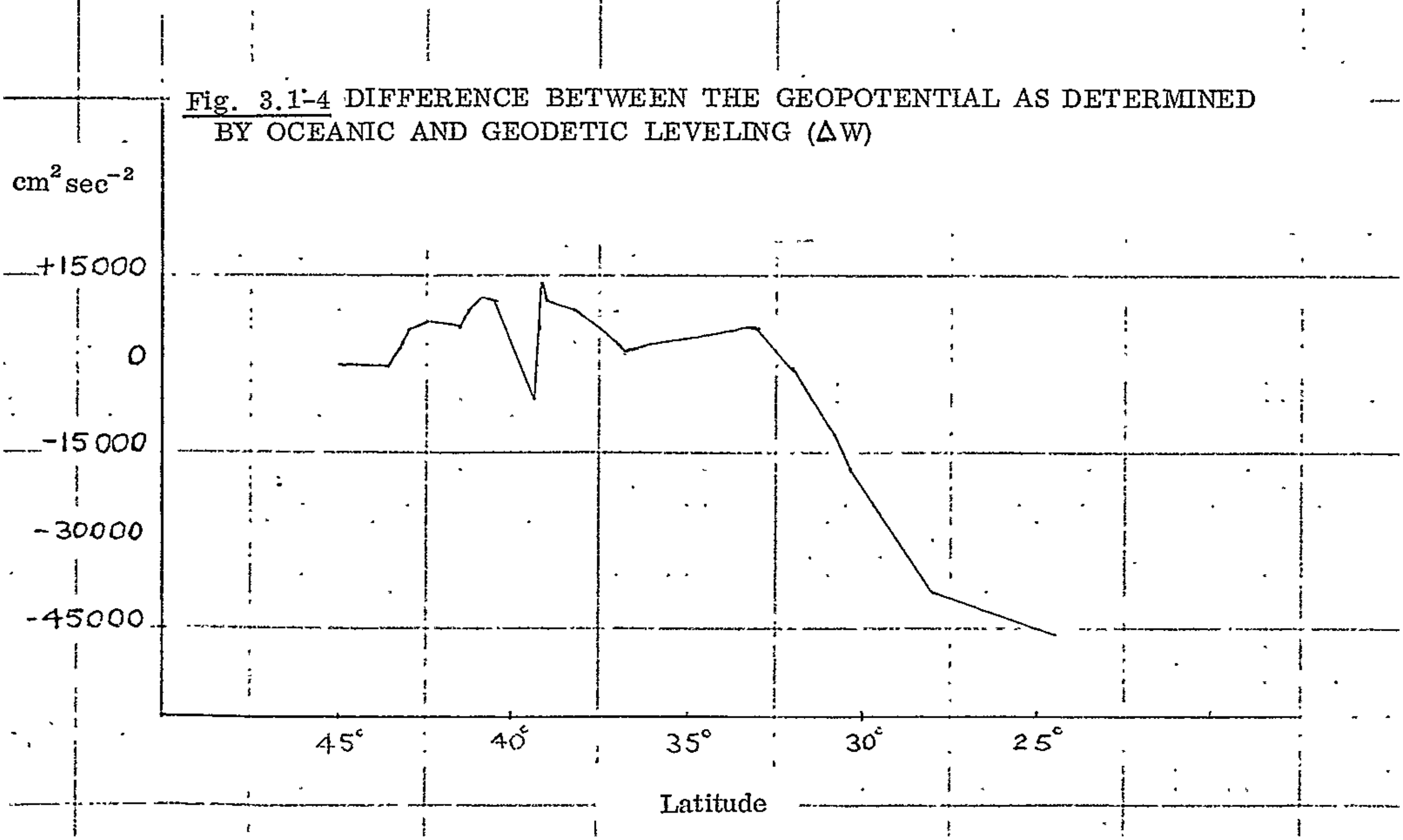


Fig. 3.1-4 DIFFERENCE BETWEEN THE GEOPOTENTIAL AS DETERMINED BY OCEANIC AND GEODETIC LEVELING (ΔW)

West Coast (East Pacific)

Fig. 3.1-5 ORTHOMETRIC HEIGHT OF OCEAN SURFACE ABOVE 1000-db SURFACE

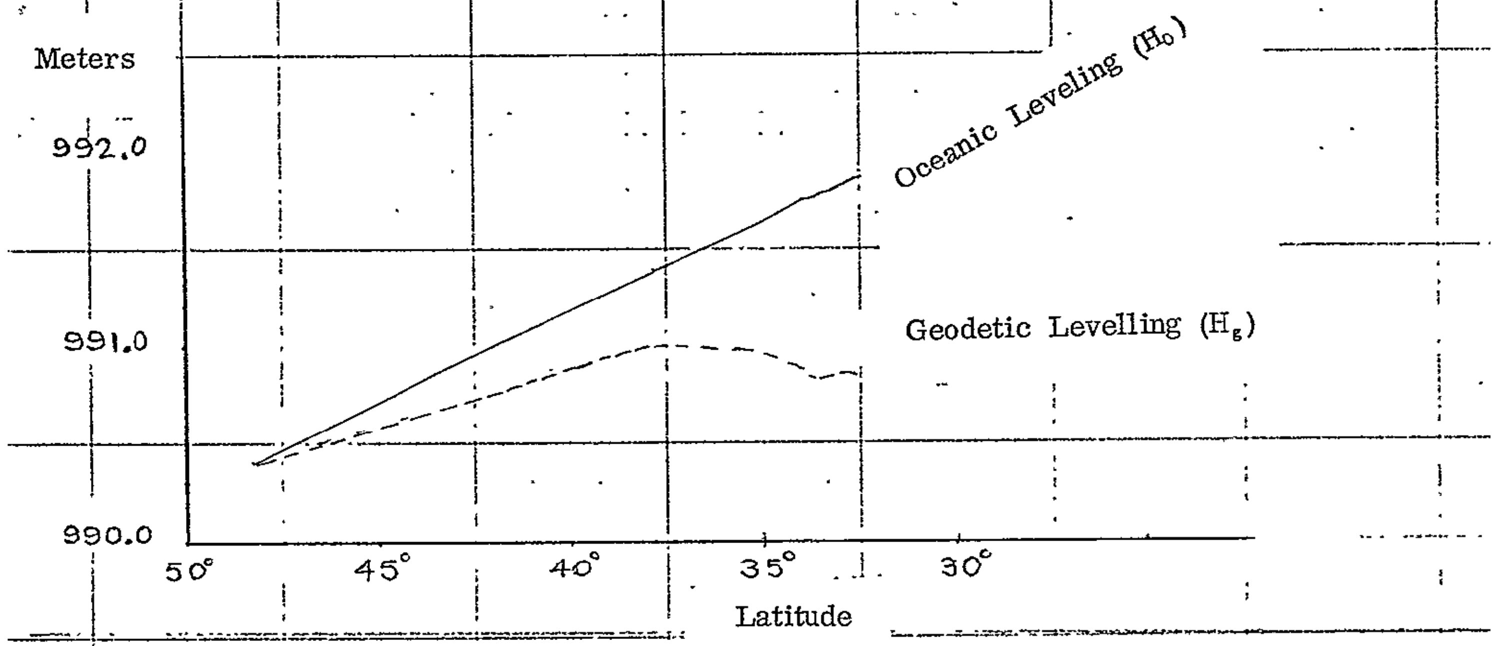
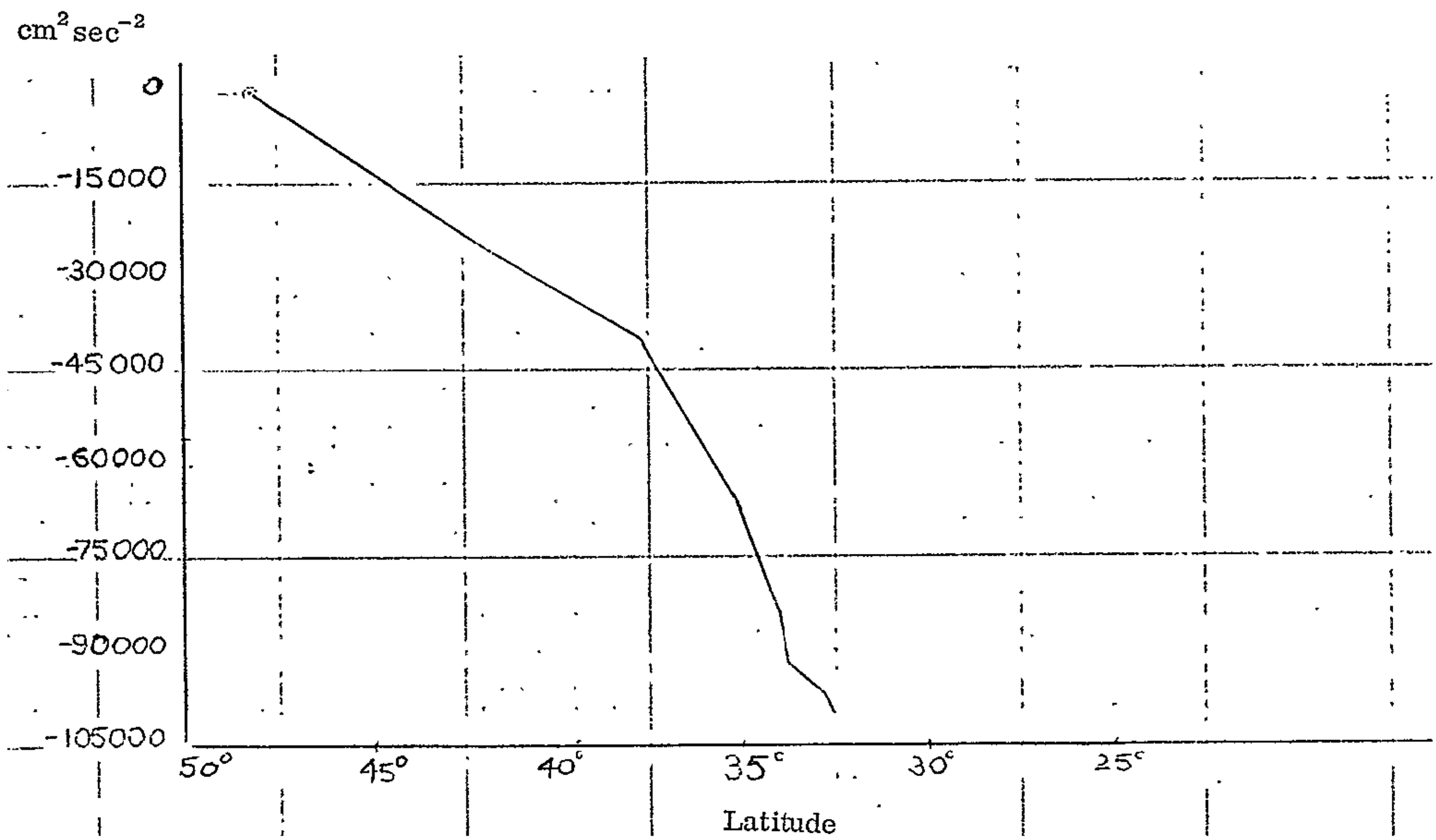


Fig. 3.1-6 DIFFERENCE BETWEEN THE GEOPOTENTIAL AS DETERMINED BY OCEANIC AND GEODETIC LEVELING (ΔW)



(iii) Height differences are more on the West Coast where the deep sea isobaric surface of reference is 1000-db, as compared to the East Coast where the reference surface is 2000-db. ΔW_1 is predominantly negative and increases with the distance from the reference station.

(iv) The crucial factors in the above comparisons are the actual gravity and the choice of deep sea isobaric surface. Actual gravity is not measured directly either by oceanographers or geodesists. Errors due to non measurement of actual gravity and to the deep sea isobaric surface not being an equipotential surface are likely to account for a small part of the discrepancy in magnitude. But the discrepancy about the direction of the slope seems to have been resolved.

(v) It is hoped that altimeter measurements from satellites will resolve the apparent discrepancy.

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1. Balazs, E., 1973. "Local Mean Sea Level in Relation to Geodetic Leveling Along the United States Coastlines," Fourth GEOP Research Conference, August 16-17, Boulder, Colorado.

2. Bjerknes, V. and Sandstrom, J. W., 1910. "Dynamic Meteorology and Hydrology," Table 7H, The Carnegie Institution of Washington, D.C.

3. Montgomery, R. B., 1973. "Departures of Sea Surface From the Geoid," Fourth GEOP Research Conference, August 16-17, Boulder, Colorado.

4. Sturges, W., 1974. "Sea Level Slope Along Continental Boundaries," JGR, Vol. 79, No. 6, p. 826.

3.2 Initial Guidelines for the Establishment of a Worldwide Geodetic Reference Frame for Geodynamics

The establishment of a Worldwide Geodetic Reference Frame (WWGRF) will be required to satisfy the geophysical needs to describe features such as continental drift, fault motions, etc.

The velocities of tectonic plates are such that observations of 10^{-9} precision (and/or accuracy: 3 cm, 0.001, 1 μ gal, I E) are required to monitor these movements.

Most likely, a Fundamental Polyhedron (FP) will serve as WWGRF. Two main aspects can be recognized:

a.) Internal motions by the points describing the FP. The most important non-common motions (relative motions) will be:

Continental drift
Fault motions
Earth-ocean tides
Ocean loading effects.

b.) External motions by the points describing the FP. The most important common motions with respect to an inertial frame (absolute motions) will be:

Precession
Nutation
Earth rotation
Polar wandering
Polar wobble.

From the observational point of view the relative motions of those FP points will be monitored with high precision in the near future. A technique such as very long baseline interferometry (VLBI) should be capable of establishing a FP with high precision.

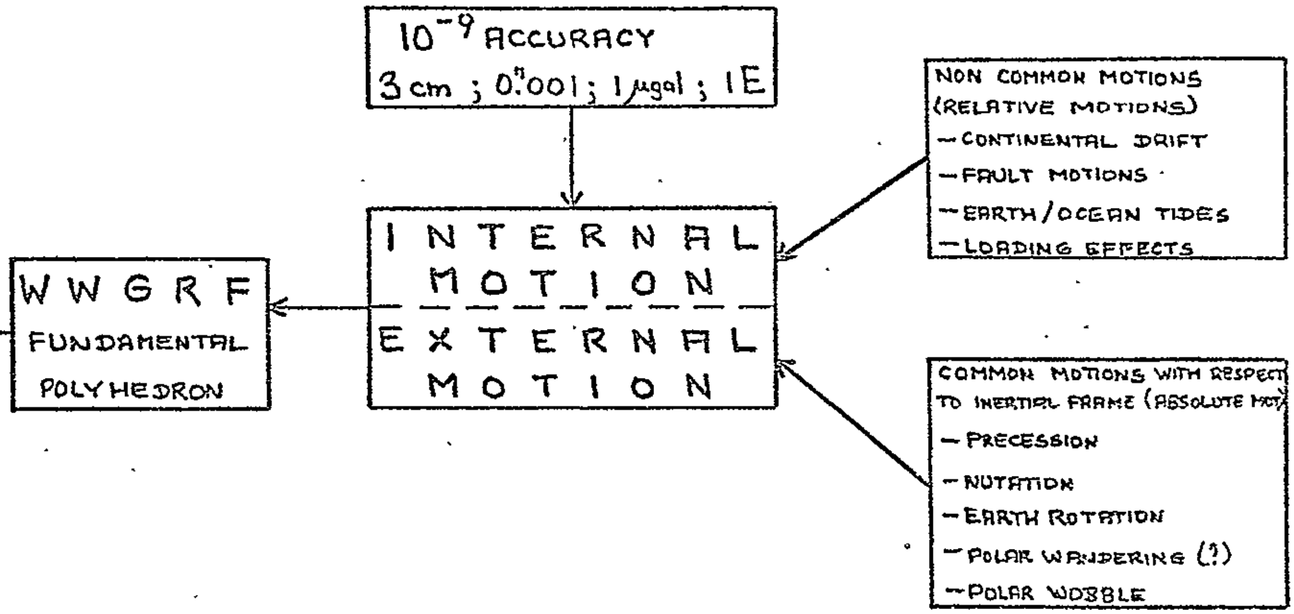
The realization of such a FP will be essentially a coordinate free problem: the shape (lenth ratios and angles) and the size (scale from the velocity of light) of a FP are the only essential features to be established. Problems of optimization from a geometrical, statistical and geophysical point of view need to be resolved.

The description of absolute motions of those FP points requires the establishment of a coordinate system which is a much more difficult and intriguing task: the orientation of a FP with respect to the inertial frame of quasars for VLBI and with respect to the inertial tensor of the earth for satellite laser ranging and the position of a FP with respect to the inertial tensor of the earth for satellite laser ranging and the positions of a FP with respect to the center of mass of the solid earth and the fluid atmosphere for VLBI and satellite laser ranging and with respect to the barycenter of the earth and the moon for lunar laser ranging.

The feasibility of the establishment of a highly accurate (10^{-9}) coordinate system which is either inertial with respect to extragalactic sources or described by the inertia tensor of the earth itself (gravity observations) needs to be investigated.

Summarizing, the problems involving the establishment of a World-wide Geodetic Reference Frame can be represented in the following schematic charts.

The Establishment of a World Wide Geodetic Reference Frame



COORDINATE FREE		n STATIONS	DESCRIBED BY	3n−6 QUANTITIES	½n(n−1) POSSIBLE QUANTITIES	CRITERIA: OPTIMIZATION (GEOMETRY + STATISTICS)	CRITERIA: GEOPHYSICS	CRITERIA: COST $
	A. SHAPE LENGTH-RATIOS V_{jik} ANGLES α_{jik}		3n−7 V,α,S			$p = \frac{\frac{1}{2}n(n-1)}{3n-6} \cong \frac{1}{6}n$ — PRECISION — ACCURACY — RELIABILITY $p \rightarrow n_1$	— NUMBER OF STATIONS PER PLATE (1,2,...) — NUMBER OF MAJOR PLATES (±12) $\rightarrow n_2$	n_3
	B. SIZE (SCALE) VELOCITY OF LIGHT c		1 c					

COORDINATE SYSTEM			NATURE OF OBSERVATIONS			CRITERIA * OPTIMIZATION	CRITERIA * GEOPHYSICS	CRITERIA * $
	C. ORIENTATION — W.R. TO INERTIAL FRAME (VLBI) — W.R. TO INERTIAL TENSOR (SATELLITE)	3 ROTATION ANGLES		LASER TO — SATELLITE — MOON	SHAPE, SCALE } GEOMETRIC SOLUTION POSITION, ORIENTATION } DYNAMIC SOLUTION			
	D. POSITION — W.R. TO CENTER OF MASS OF SOLID EARTH + FLUID ATMOSPHERE	3 DISTANCES (COORDINATES)		VLBI TO — QUASARS — PLANETS — MOON — SATELLITE	SHAPE SCALE ORIENTATION			
				GRAVITY				

* TO BE INVESTIGATED

TYPES OF OBSERVATIONS AND THEIR PROBLEM AREAS

A1 LASER TO SATELLITE

POSITION : FROM DYNAMICAL SOLUTIONS :
C_{nm}, S_{nm} → ORBIT → INFLUENCE ON CENTER OF MASS (GEOCENTER) DUE TO
- CUT OFF POINT AFTER N DEGREE, ORDER OF SPHERICAL HARMONICS
- EXPANSION
- REFRACTION, DRAG, RADIATION, TIDES

ORIENTATION: WITH RESPECT TO INERTIA TENSOR (C_{nm}, S_{nm})

A2 LASER - TO MOON

POSITION : WITH RESPECT TO EARTH-MOON BARYCENTER

ORIENTATION : FROM EPHEMERIS

B VLBI

ORIENTATION : - PRECESSION, NUTATION OBTAINED WITHOUT A PRIORI KNOWLEDGE
- POLAR MOTION OBTAINED INSTANTLY

POSITION : ???

REFERENCE FRAME : POLYHEDRON OF QUASARS (FEDOROV) WHEREBY ONLY ANGULAR DISTANCES BETWEEN QUASARS ARE DETERMINED
- EXTENSION OF EXTRAGALACTIC SOURCES (0".01) MAY FORM A PROBLEM

REALIZATION

DATA

A. International Motion Service (I.M.S.)

Monitors, models the motion of the fundamental polyhedron with respect to the quasar polyhedron

- Rotation (UT)
- Polar motion
- Precession, nutation

B. Fundamental Polyhedron Service (F.P.S.)

- Removes common motion from all points as determined, modeled by I.M.S.
- Monitors, models non common (inertial) motion of all points about modeled mean positions and motions
- Modeled mean positions determine WWGRF at some epoch T_0

  Note: 3 points necessary to define a coordinate system: e.g. 3 points on the American, EurAsian and Antarotic plate because of their smallest relative motions
- Updates mean positions + modeled motions if necessary

References

IAU Colloquium No. 26 on "Reference Coordinate Systems for Earth Dynamics," Torun., Poland, August 26-31, 1974:

a. Bender, P.L., "Reference Coordinate System Requirements for Geophysics"

b. Fedorov, E.P., "Magnitudes and Spectra of Important Dynamical Phenomena"

c. Krasinsky, G.A., "On Constructing the Inertial System of High Accuracy by VLBI Methods"

d. Newton, R.R., "Coordinates used in Range or Range-Rate Systems, and their Extension to a Dynamic Earth"

e. Zhongolovitch, I., "The Role of VLBI in the Establishment of Coordinate Systems"

f. "Requirements, Concepts, Realization and Corrections as collected by four Colloquium Working Groups".

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Van Gelder, B. H. W., 1974. "The LAGEOS Problem," Second Semi-annual Status Report, NGR 36-008-204, pp 58-82, July.

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3.3 Computer Programs Acquisition

3.31 Analytical Lunar Ephemeris of Deprit

In order to make use of lunar ephemeris (kept at system: Tape No. UC2999 - Slot No. 049) and clarify certain doubts, M. Kumar made a trip to the University of Cincinnati on November 25, 1974 to meet Dr. Andre Deprit. The relevant information and various points clarified during discussion are as under:

(a) The various constants used in the development of the ephemeris:

(i) Mean Anomaly of Moon

at time T $(\ell_T) = \ell_0 + n_\ell (T - T_0)$

(ii) Mean Anomaly of Sun

at time T $(\ell_T') = \ell_0' + n_{\ell'} (T - T_0)$

(iii) Argument of Perigee

at time T $(g_T) = g_0 + n_g (T - T_0)$

(iv) Longitude of Node

at time T $(h_T) = h_0 + n_h (T - T_0)$

where

T_0 = 1900 January $0^d.5$ E.T. (MJD 15019.5)

n_ℓ = 1732559353″.561 / Julian Century

$n_{\ell'}$ = 129597742″.380 / Julian Century

n_g = 14642682″.579 / Julian Century

n_h = -6967199″.408 / Julian Century

ℓ_0 = 5.168000340 radians *

ℓ_0' = 6.256583523 radians *

g_0 = 1.311550024 radians *

h_0 = 4.523601515 radians *

Then

$$F_T = \ell_T + g_T$$

$$D_T = \ell_T + g_T + h_T - \ell_T' .$$

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* Taken from Supplement to AENA, 1961, pp 44.

* Taken from Supplement to AENA, 1961, pp 44 as $(F_0 - \ell_0)$.

$$e'(\text{sun}) = 0.01675104$$

$$\Pi_{MOON} = 3422''.452.$$

(b) The parameters used are:

$m = n'(\text{sun}) / n\,(\text{moon})$

e = Eccentricity of the lunar orbit

e' = Eccentricity of the sun orbit

Υ = Constant of lunar inclination $(\sin i/2)$

$\alpha = (1 - 2\sigma)\, {}^{a}/_{a'}$ **

where

a = Semi major axis of lunar orbit

a' = Semi major axis of sun orbit

$$\sigma = \frac{M_{MOON}}{M_{EARTH} + M_{MOON}}$$

** Refer to Boeing Scientific Research Lab. Document No. D1-82-0963, March, 1970, (pp 4, 6, 8); "Analytical Lunar Ephemeris - Definition of Main Problem" by A. Deprit, J. Henrard and A. Rom.

(c) All coefficients on the tape are in arc of seconds. Three files contain information about longitude, latitude and parallax of the moon in terms of Delaunay arguments and partial derivatives with respect to five arguments vide section (b) above.

(d) In the discussion it was brought out by Dr. Deprit that even though his ephemeris contains only the main problem, the partials available as computed from the tape for any epoch should be compatible in accuracy for a least square adjustment. He further suggested that certain coefficients in the order of 10^{-6} or smaller may also be omitted while computing partials so as to improve the computational time.

(e) This ephemeris does contain Van Flandern's correction [1969]

between constants of lunar theory and FK4 system.

3.32 Numerically Integrated Lunar Ephemeris of JPL

A new lunar ephemeris (which is kept at System: Tape No. LURE02, Slot No. 4126) is detailed in Attachment 1.

3.33 Goddard Trajectory Determining System (GTDS)

During the report period Goddard Space Flight Center, Greenbelt, Maryland, was approached to acquire latest computer program for artificial satellite orbit generation/data simulation.

The program obtained by us forms the part of GSFC's comprehensive computer program, "Goddard Trajectory Determining System (GTDS)" and contains mainly the orbit generation and data simulation capabilities. The relevant information and details about the tapes containing the program are:

<u>Tape Name — ORBIT 1</u>

Where Lodged — Room No. 404 Cockins Hall, OSU

Remarks: The tape contains 5 files.

1. Source deck listing
2. Overlay structure
3. Load module created from file 1 & 2;
4. Solar lunar planetary ephemeris in 1950.0 mean reference frame for period of January 1971 to November 1981
5. Information as in file 4 in true of date system.

<u>Tape Name — ORBIT 2</u>

Where Lodged — Room No. 404 Cockins Hall, OSU

Remarks: Defines time and polar motion coefficients.

<u>Tape Name — GTDS01</u>

Slot No. — H073

Where Lodged — Systems Engineering, OSU

Remarks: File No. 1 - Source deck information as unloaded data set.

If the source deck is required at any time then data set has

File No. 2 — Load module as partition data set (member name - GTDS). Program is being set up on the system disk as ORBGEN.GTDS.NEWLOAD for use and renamed as 'MAN.' This renaming became necessary due to modification in main program (subroutine: ODSEXEC in GTDS) to suit the computer system at OSU (see attachment 4).

<u>Tape Name — GTDS02</u>

Slot No. — H120

Where Lodged — Systems Engineering, OSU

Remarks: File Nos. 1 to 20 — Data and various constants information to be used with program GTDS. Available on the system disk IRCC71 and IRCC74 as permanent sequential data sets.

File No. 21 — Information about overlay structure for use with GTDS (see details in Attachment 2).

File No. 22 — Information about Goddard Space Flight Center procedure as used by them to run the program GTDS. (See details in Attachment 3).

<u>NOTE:</u>

(i) As the computer at OSU generally works with limited number of disk units, a special object deck was obtained from Mr. P. Pandhi of IRCC for inclusion in overlay structures while setting up of the load module. (See JCL set up listing in Attachment 4).

(ii) The program GTDS can now be run at OSU as it is or with over-riding subroutine temporarily. The required JCL set ups for these two cases are shown as Attachment 5 and Attachment 6, respectively.

(iii) The Tapes Nos. ORBIT1 and ORBIT2 contain only the orbit generation capability of GTDS.

JET PROPULSION LABORATORY

ENGINEERING MEMORANDUM

391-605

10 December 1974

TO: Distribution

FROM: J. G. Williams and W. S. Sinclair

SUBJECT: LURE 2 Ephemeris

The LURE 2 ephemeris (LE 40) is a new lunar ephemeris based on lunar laser ranging data. The data span for the fit was August 1969 to June 1974, but the first year of data was very sparse. 1252 ranges to the Apollo 11, 14, 15 and Lunokhod 2 reflectors were fit with an rms residual of 45 cm.

The list of constants used in the integration is given in this memo. In many cases the number of digits given in a constant exceeds the significant digits of that constant. The earth harmonics are from the 1973 SAO standard earth III model. The lunar harmonics C_{30}, C_{32}, S_{32}, and S_{33} were derived from the laser ranging data while the remaining harmonics were adopted from the lunar orbiter work. C_{20} and C_{22} were adjusted from lunar orbiter values so that their ratio matches the constraint imposed by β and γ. The mass of the earth-moon system was determined from the lunar laser data while the earth-moon mass ratio is adopted from spacecraft tracking results. The newly adopted speed of light was used in this work but parameters scaled to the old value are given for comparison. The new speed of light is recommended by both the IAU and the International Committee for Weights and Measures and we do encourage that it be used in all future astronomical and geodetic work for compatibility.

The relativistic effects have been chosen so that the time argument of the ephemeris is heliocentric coordinate time and the space components of the moon are differenced heliocentric coordinates of the earth and moon An isotropic line element is used. The accelerations due to the earth's figure include the leading term of nutations and the lunar figure effects include the most important terms of physical librations in longitude. The tidal friction effect is modeled as a perturbation from a tidal bulge raised on the earth by the moon and phase shifted in right ascension by a constant phase lag. For the secular acceleration of the moon's orbital longitude the product of the Love number k_2 and the phase lag δ has been chosen to approximately reproduce the value of $\frac{1}{2}\dot{n} = -20''/\text{century}^2$, a value close to that of several recent investigations. At present the lunar laser data is not able to significantly correct this number though this should soon become possible.

The planetary ephemeris was integrated simultaneously with the moon. The starting conditions for the planets were modified from DE84. The modifications consisted of the new earth-moon mass and a rotation of the orbit planes of the four inner planets to match obliquity and equinox corrections derived from the lunar laser data analysis. The corrections make the lunar and planetary orbit planes and the earth's equatorial plane consistent at the present time. The zero point of right ascension is not adjusted to the dynamical equinox. The inner planets were rotated together because the planetary ranging data tends to determine the relative orientations of their orbital planes well. The cause of this rotation is still under investigation and as a consequence this planetary ephemeris is considered highly experimental. The planetary ephemeris with

the lunar ephemeris is designated DE86 and resides on J663 in the type 50 format. Type 66 tapes are also available.

The radial earth-moon distance is uncertain by a constant, corresponding to the mass of the system, which is $\lesssim$ 30m. Uncertainties in variations of the radial component apart from the constant are $\lesssim$ 1.5m. The uncertainty in relative celestial longitudes is thought to be less than a few thousandths of a second of arc while the zero point matches that of the earth-moon barycenter in the planetary ephemeris at the present time. Celestial latitudes in the sense of relative earth equatorial, earth orbital, and moon orbital planes are thought to be better than a few hundredths of a second of arc. The above numbers apply to the time span of the fit, the errors increasing in the past or future.

Span of integration	2440400.5 - 2444000.5
Span of type 50 tape	2440424.5 - 2443960.5
Mass ratio earth/moon	81.3007
Mass ratio sun/(earth+moon)	328900.526
GM barycenter	8.997012 315 $\times 10^{-10}$ au^3/d^2

	Old c	New c
c	299 792.5	299 792.458 km/sec
AU	149 597 891.916 95	149 597 870.95869 km
GM sun	132 712 496 508.11	132 712 440 729.53 km^3/sec
GM earth	398 600.6538	398 600.4854 km^3/sec^2
GM moon	4902.7948	4902.7894 km^3/sec^2
REM (type 50 tapes only)	6378.15009	6378.14920 kms

Earth Parameters

$J_2 = 1082.637 \times 10^{-6}$

$J_3 = -2.541 \times 10^{-6}$

$J_4 = -1.618 \times 10^{-6}$

Earth radius used with harmonics 6378.156 kms

Potential Love number $k_2 = 0.29$

Tidal phase lag $\delta = 0.0713$ radians

Lunar Parameters

Harmonics (units of 10^{-6}

$C_{20} = -203.822$	
$C_{22} = 22.396$	$S_{22} = 0.0$
$C_{30} = -10.44$	
$C_{31} = 28.6$	$S_{31} = 8.8$
$C_{32} = 4.82$	$S_{32} = 1.71$
$C_{33} = 2.7$	$S_{33} = -1.14$

Radius used with harmonics 1738.09 kms

Harmonics consistent with $C/MR^2 = 0.394$

Tilt of moon's pole to ecliptic, I = 5552.7"

JGW/WSS:mpg

Distribution

J. D. Anderson
P. B. Esposito
M. S. Keesey
J. H. Lieske
W. G. Melbourne
X X Newhall
C. F. Peters
W. L. Sjogren
E. M. Standish
M. A. Slade
D. W. Trask

```
ENTRY MAIN
 REPLACE BLKLET,PLTDMP,QUICKY,TYPLIN,UCS,TYPWRITE
INCLUDE  TAPELIB
REPLACE RTOBS,VPFORC,GOFUNO,GO24,SELRUN
INCLUDE SYSLIB(GTDS)
OVERLAY REG1SEG1
INSERT READER,IHCSLOG,IHCSSCN,IHCFRXPI,IHCFRXPR,IHCSEXP,GSCALE,CPLOT$
 INSERT DATE,EDITT,GRID,GRDNUM,HORLIN,MINT,PLOTST,SCHAR,SC4020,TIMING
OVERLAY  REG1SEG1
INSERT   ORBIT,INTP
INSERT   WORKER,HEMITR,TIMREG,VCROSS
OVERLAY  REG1SEG2
INSERT  FORCES,DPART,SECHEK,SECUPD,DFIX,INV2,OSMEAN,BRWORB,DKEPLR
OVERLAY  REG1SEG3
INSERT  ORBITB,RESINB,INTOGA,BROCOR
OVERLAY  REG1SEG3
INSERT         CSHAD,AERO,DRAGV,FAPX,FORCV,HARMON,HARMV,HEIGHT
INSERT        PMASS,PMASSV,SECHKN,SLRADV,SOLRAD,SPART,MANEUV
INSERT    SUMS,TESTH,TWOBDY,VARFRC,RESUME,SPARTV
INSERT   GMTRA,TOBODY
INSERT ANPART,BURN,BURNV,SCATT,TKPTC
OVERLAY REG1SEG4
INSERT COVUP,SOLTAB,GVCVL,SYMINV
OVERLAY REG1SEG4
INSERT LG5,PARTE
OVERLAY REG1SEG4
INSERT ATMOS
OVERLAY REG1SEG4
INSERT JACROB,DRAGCN
OVERLAY REG1SEG5
INSERT LOWALT,ROOTS
OVERLAY REG1SEG6
INSERT DIFFDE
OVERLAY REG1SEG6
INSERT BARODE
OVERLAY REG1SEG5
INSERT HIALT,JACCWF
OVERLAY  REG1SEG2
INSERT   GETHDR,ORBITF,INTOGF,ERRGET
OVERLAY  REG1SEG3
INSERT   GREC1,OUTEC1
INSERT CMPVCT,GREC2,OUTEC2
OVERLAY  REG1SEG3
INSERT DSPING,DSPCBK,DSPFL,TPSCHL
OVERLAY REG1SEG4
INSERT INTDEP,OUTDS1,EVENT,GETDSP,GRDSI
OVERLAY REG1SEG4
INSERT DSPSUM,GAUSS,DODSWR,OUTDS2,SCHDUL,NOCCLT,RANDU
OVERLAY REG1SEG4
INSERT OUTDS3,GDSSUM,STARPT,BCD
OVERLAY  REG1SEG1
INSERT WFCONT
OVERLAY REG1SEG2
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INSERT IRWF,IONGEN,SOLGET,REFGEN,MAGFRT,SICORT,DKSIRT,GKRT           OVLY 108
INSERT DKGKRT,IGETRT,COEFF1                                          OVLY 110
INSERT IRWCSC,COEF1,NBSDAT                                           OVLY 112
OVERLAY  REG1SEG2                                                    OVLY 114
INSERT DODSEL,ELSWF,ELSGET                                           OVLY 116
INSERT ATMWF,ICWF,MANWF,PCWF,SECWF,SETLIF                            OVLY 118
OVERLAY  REG1SEG2                                                    OVLY 120
INSERT OBSWF,REJRPT                                                  OVLY 122
OVERLAY  REG1SEG3                                                    OVLY 124
INSERT   REFRMT,DWRITE,UPSTAT,OBSCRD,SELCON,DODSDT                   OVLY 126
INSERT   DODSOB,GEOWF,USBOBS,PCERD,GEOCON,GETGEO                     OVLY 128
OVERLAY  REG1SEG3                                                    OVLY 130
   INSERT SORTIT,SORTOB,SORTB                                        OVLY 132
OVERLAY  REG1SEG2                                                    OVLY 134
INSERT   SLPEPH                                                      OVLY 136
INSERT   AMATRX,CMATRX,GETTAP,INPUT1,CHEBY,READE,SLPTAP              OVLY 138
INSERT   CETBL1,CETBL3,CETBL4,CETBL9,SAVE,INPUT,SLPWF,CHEV           OVLY 140
OVERLAY  REG1SEG4(REGION)                                            OVLY 142
INSERT   CROSSV,RESINV,MULSTP,USER,USE,ORBITV                        OVLY 144
OVERLAY REG1SEG5                                                     OVLY 146
INSERT   INARRY,DPX2EL                                               OVLY 148
OVERLAY REG1SEG5                                                     OVLY 150
INSERT CETODS                                                        OVLY 152
OVERLAY REG1SEG5                                                     OVLY 154
INSERT ASCOEF,IBINC,RESWRV,APPSUM                                    OVLY 156
INSERT PARCOR                                                        OVLY 158
OVERLAY REG1SEG5                                                     OVLY 160
INSERT  CSTFPX,EQUMTN,AVRAGE,INTPAR                                  OVLY 162
OVERLAY REG1SEG6                                                     OVLY 164
INSERT   DPEL2X,FUNCTE                                               OVLY 166
OVERLAY REG1SEG6                                                     OVLY 168
INSERT        PERFOR,CAPEFO,COMATD,FIDPAR,HEMIDS,DSTOCE              OVLY 170
OVERLAY REG1SEG6                                                     OVLY 172
INSERT EQUNPV,PARTEQ,AVSTRT,GQFUN,VOQUAD                             OVLY 174
OVERLAY REG1SEG6                                                     OVLY 176
INSERT DQRTIC,DCUBIC                                                 OVLY 178
OVERLAY REG1SEG6                                                     OVLY 180
INSERT   IDLPV,IPART                                                 OVLY 182
OVERLAY REG1SEG6                                                     OVLY 184
INSERT   DALLPV,PARDT                                                OVLY 186
OVERLAY REG1SEG5                                                     OVLY 188
INSERT ISTART                                                        OVLY 190
OVERLAY REG1SEG5                                                     OVLY 192
INSERT   IDEAL,CNVPV                                                 OVLY 194
OVERLAY  REG1SEG4                                                    OVLY 196
INSERT  SETORB,SATTIP,AEROPR                                         OVLY 198
OVERLAY  REG1SEG4                                                    OVLY 200
INSERT   ORBITT,COPS,CROSST,CHIRP,VARARR,CO,EVA,EVAPT,INTEGT         OVLY 202
INSERT CHETO,TCTP,PDP,EATRAN,CHVTP                                   OVLY 204
OVERLAY  REG1SEG5                                                    OVLY 206
INSERT   RESNTT                                                      OVLY 208
OVERLAY  REG1SEG5                                                    OVLY 210
INSERT   RESWMT                                                      OVLY 212
OVERLAY  REG1SEG4                                                    OVLY 214
INSERT   INTUGN,NEPOCH,HARM                                          OVLY 216
OVERLAY  REG1SEG4                                                    OVLY 218
INSERT ORBINT                                                        OVLY 220
OVERLAY  REG1SEG4                                                    OVLY 222
INSERT   CROSSR,EQMOTR,ORBITR                                        OVLY 224
OVERLAY  REG1SEG5                                                    OVLY 226
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INSERT   RESINR,RKS8R                                                        OVLY 228
OVERLAY  REG1SEG5                                                            OVLY 230
INSERT   CSTEPR,RSWRMR                                                       OVLY 232
OVERLAY  REG1SEGA                                                            OVLY 234
INSERT   ORBITC,RKG4                                                         OVLY 236
OVERLAY  REG1SEGB                                                            OVLY 238
INSERT NEWTAB                                                                OVLY 240
INSERT   CSTEP                                                               OVLY 242
OVERLAY  REG1SEGB                                                            OVLY 244
INSERT  CROSSC,RESINC                                                        OVLY 246
OVERLAY  REG1SEG5                                                            OVLY 248
INSERT   XSUM                                                                OVLY 250
OVERLAY REG1SEG6                                                             OVLY 252
INSERT   MSTART,XCOR,XDCOR                                                   OVLY 254
OVERLAY REG1SEG6                                                             OVLY 256
INSERT   RESWRM                                                              OVLY 258
OVERLAY REG1SEG5                                                             OVLY 260
INSERT RKS8                                                                  OVLY 262
OVERLAY  REG1SEG4                                                            OVLY 264
 INSERT RPDATO                                                               OVLY 266
OVERLAY  REG1SEG5                                                            OVLY 268
INSERT RUNACC,STADRO,OUTDC6                                                  OVLY 270
OVERLAY  REG1SEG5                                                            OVLY 272
INSERT SCAN,UPCOV,GETOBN,SCALE                                               OVLY 274
OVERLAY  REG1SEG4                                                            OVLY 276
INSERT EOFLTR                                                                OVLY 278
OVERLAY  REG1SEG5                                                            OVLY 280
INSERT EGAUSS                                                                OVLY 282
OVERLAY  REG1SEG5                                                            OVLY 284
INSERT DOUBLR                                                                OVLY 286
OVERLAY  REG1SEG5                                                            OVLY 288
INSERT POSFIX                                                                OVLY 290
OVERLAY  REG2SEG1(REGION)                                                    OVLY 292
INSERT   NOREST,RESTAT,GRDCO                                                 OVLY 294
OVERLAY  REG2SEGH                                                            OVLY 296
INSERT ANTRA,OBS,OBSCOR,OBSP,OBSRD,READWF,SORREG,TRANF,OBSUSB,OBSUS1         OVLY 298
INSERT   TRUANO,WEIGHT,OUTDC5,IBPNT,CNVPCK,MA1333,OBSED,TCONVO,ITERCT        OVLY 300
OVERLAY REG2SEG3                                                             OVLY 302
INSERT CORDBA,LCLARG                                                         OVLY 304
INSERT ION,BETA,COEFF2,MODEL                                                 OVLY 306
OVERLAY REG2SEG5                                                             OVLY 308
OVERLAY REG2SEG5                                                             OVLY 314
INSERT  PRFLRT,INTERP,REFGET,TABLES                                          OVLY 316
OVERLAY REG2SEG3                                                             OVLY 318
INSERT CORCSC,REFCON,IONOSP,SZZ,VCROSW                                       OVLY 320
OVERLAY  REG2SEGH                                                            OVLY 322
INSERT   IHCLSCNH,INVL                                                       OVLY 324
INSERT   OUTPUT,SPAT,ELEME,ROTRAN,KPART,PPART,CELEM,POLAR,SCART,ROT          OVLY 326
INSERT CAIRS                                                                 OVLY 328
OVERLAY  REG2SEG2                                                            OVLY 330
INSERT         OUTDC4,OUTDC3,OUTDC7,OUTDC2,OUTDC8                            OVLY 332
OVERLAY  REG2SEG2                                                            OVLY 334
INSERT ORBOUT,ORBOUT2,GROEFI,CONSC2,OUTLIF,DIFD,MINSTR,SHORTP                OVLY 336
INSERT   EPHEM                                                               OVLY 338
INSERT   ORB1                                                                OVLY 340
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OVERLAY REG2SEG2                                                          OVLY 342
 INSERT W24WF,OBSAVE                                                      OVLY 344
OVERLAY  REG2SEG2                                                         OVLY 346
 INSERT   ADVANS                                                          OVLY 348
OVERLAY REG2SEGA                                                          OVLY 350
 INSERT GRDCRS,COMPER                                                     OVLY 352
OVERLAY REG2SEG3                                                          OVLY 354
 INSERT GRDCI,IHCFMAXI                                                    OVLY 356
OVERLAY REG2SEG4                                                          OVLY 358
 INSERT GRSLVA                                                            OVLY 360
OVERLAY REG2SEG4                                                          OVLY 362
 INSERT GREDIT                                                            OVLY 364
OVERLAY REG2SEG3                                                          OVLY 366
 INSERT   GREPAD                                                          OVLY 368
OVERLAY REG2SEG3                                                          OVLY 370
 INSERT GRPEL                                                             OVLY 372
OVERLAY REG2SEG3                                                          OVLY 374
 INSERT GR24HH                                                            OVLY 376
OVERLAY REG2SEG3                                                          OVLY 378
 INSERT GRDCON                                                            OVLY 380
OVERLAY REG2SEG3                                                          OVLY 382
 INSERT GRBIAS                                                            OVLY 384
OVERLAY  REG2SEGA                                                         OVLY 386
 INSERT   INTDC,EIGEN,CHIN,SOLVGP                                         OVLY 388
OVERLAY  REG2SEG3                                                         OVLY 390
 INSERT   SLOBT,CONDR                                                     OVLY 392
OVERLAY  REG2SEG3                                                         OVLY 394
 INSERT   OUTDC1,OUTOG1                                                   OVLY 396
OVERLAY  REG2SEG4                                                         OVLY 398
  INSERT OUTSLV,OUTCOR                                                    OVLY 400
OVERLAY  REG2SEG4                                                         OVLY 402
  INSERT OUTEDT,OUTOUT,OUTSEC,OUTPHC,OGCROS                               OVLY 404
OVERLAY  REG2SEG4                                                         OVLY 406
  INSERT OUTCRD,OUTGEN,OUTTIC                                             OVLY 408
OVERLAY  REG2SEG2                                                         OVLY 410
 INSERT PSET,MATCON,ELSIG,ELSIG1,PPLHXY                                   OVLY 412
OVERLAY  REG2SEG2                                                         OVLY 414
 INSERT GRREPT,GRDC2,GRPROM,FDORB                                         OVLY 416
OVERLAY  REG2SEG2                                                         OVLY 418
 INSERT GRPMEN,GENONE.GENTWO,GRSORT,IHCGSP04,WAIT,GRPLOT,GRTRAK           OVLY 420
OVERLAY  REG2SEG2                                                         OVLY 422
 INSERT   IGRAPH,IGRPH2                                                   OVLY 424
OVERLAY REG2SEG1                                                          OVLY 426
 INSERT GETCMP.CMPOPT,PLOTTP                                              OVLY 428
OVERLAY  REG2SEG1                                                         OVLY 430
 INSERT   OUTSG,PLHXYZ                                                    OVLY 432
OVERLAY  REG2SEG2                                                         OVLY 434
 INSERT   WRKREP                                                          OVLY 436
 INSERT   OUTWAD,OUTWEL,OUTWIC,OUTWMN,OUTWPC,OUTWSC,OUTWIR,OUTWOB         OVLY 438
 INSERT   OUTWSL,OUTWTC                                                   OVLY 440
OVERLAY  REG2SEG2                                                         OVLY 442
 INSERT   PERCON                                                          OVLY 444
 INSERT   OUTPAD,OUTPEL,OUTPIC,OUTPIR,OUTPOB,OUTPPC,OUTPSL                OVLY 446
 INSERT   OUTPTC,OUT24H,OUTPMN,OUTPSC                                     OVLY 448
OVERLAY  REG3SEG1(REGION)                                                 OVLY 450
 INSERT   EPHGEN                                                          OVLY 452
OVERLAY  REG3SEG2                                                         OVLY 454
 INSERT   OUTOG2,OUTOG3,OUTOG4,OUTPAR,PRINT,UNIT,OUTMAP                   OVLY 456
OVERLAY  REG3SEG2                                                         OVLY 458
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 INSERT    ACWFRP,ADWFRP,EPWFRP,FSWFRP,IGRPH2,LPWFRP,OGMENU            OVLY 460
OVERLAY   REG3SEG2                                                     OVLY 462
 INSERT    OGBUG                                                       OVLY 464
OVERLAY   REG3SEG1                                                     OVLY 466
 INSERT EPHCMP,RDORB1,ADDYMD,ADTIME                                    OVLY 468
OVERLAY   REG3SEG1                                                     OVLY 470
 INSERT    DCING,DCFL,DCBUG,STAGE1                                     OVLY 472
OVERLAY   REG3SEG2                                                     OVLY 474
 INSERT    DC,ITERCT                                                   OVLY 476
OVERLAY   REG3SEG2                                                     OVLY 478
 INSERT    DSPEXC                                                      OVLY 480
OVERLAY REG3SEG1                                                       OVLY 482
 INSERT GRERR,DUMPER                                                   OVLY 484
OVERLAY   REG3SEG1                                                     OVLY 486
 INSERT    SETRUN,MSGWTR,OKERR,CKSCOP                                  OVLY 488
OVERLAY   REG3SEG2                                                     OVLY 490
 INSERT    SETANL                                                      OVLY 492
OVERLAY   REG3SEG2                                                     OVLY 494
 INSERT    SETCMP                                                      OVLY 496
OVERLAY   REG3SEG2                                                     OVLY 498
 INSERT    SETDC                                                       OVLY 500
OVERLAY   REG3SEG2                                                     OVLY 502
 INSERT    SETDM,DIFF                                                  OVLY 504
OVERLAY   REG3SEG2                                                     OVLY 506
 INSERT   SETRPT,SETPFR                                                OVLY 508
OVERLAY REG3SEG2                                                       OVLY 510
 INSERT CRTIN,GRCARD,RDPDS,CSTAE,INTGR                                 OVLY 512
OVERLAY REG3SEG1                                                       OVLY 514
 INSERT EARLYO,SECULA,RANGLE,EO,ELEMGN,ANGLES,POLRT                    OVLY 516
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```
//GTDS PROC MODULE=GTDS,SORT='DUMMY,',GRAPH='DUMMY,',UNIT=2250
//S1      EXEC PGM=IEFBR14
//DD1 DD DSN=GJFEM.GTDS.LOADMOD.LOAD(&MODULE),DISP=(SHR,PASS)
//****OWNER'S PGM'MER ID: "GJFEM" ****              UPDATED 28JUN74
//GO      EXEC PGM=*.S1.DD1,REGION=490K
//FT01F001 DD DISP=SHR,DSN=GJFEM.GTDS.DIRECTRY.DATA,DCB=BUFNO=1
//FT02F001 DD DISP=SHR,DSN=GJFEM.GTDS.ATMOSDEN.DATA,DCB=BUFNO=1
//FT03F001 DD DISP=SHR,DSN=GJFEM.GTDS.MANEUVER.DATA,DCB=BUFNO=1
//FT04F001 DD DISP=SHR,DSN=GJFEM.GTDS.ASTROCON.DATA,DCB=BUFNO=1
//FT05F001 DD DDNAME=DATA5
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),
//             SPACE=(CYL,(3,1),RLSE)
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800,BUFNO=1)
//FT08F001 DD DISP=SHR,DSN=GJFEM.GTDS.EARTHFLD.DATA,DCB=BUFNO=1
//FT09F001 DD DISP=SHR,DSN=GJFEM.GTDS.LUNARFLD.DATA,DCB=BUFNO=1
//FT10F001 DD DISP=SHR,DSN=GJFEM.GTDS.INTCOEF.DATA,DCB=BUFNO=1
//FT11F001 DD DISP=SHR,DSN=GJFEM.GTDS.SECTIONS.DATA,DCB=BUFNO=1
//FT12F001 DD &GRAPH.UNIT=DISK,   TEMPORARY DATA FOR CRT INPUT MODE
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=2000,BUFNO=1),
//             DISP=(NEW,DELETE),SPACE=(TRK,(1,1)),DSN=&&INPROMPT
//FT13F001 DD DISP=SHR,DSN=GJFEM.GTDS.ERRORMSG.DATA,DCB=BUFNO=1
//FT14F001 DD DISP=SHR,DSN=GJFEM.GTDS.SLP1950.DATA,
//             LABEL=(,,,IN),DCB=BUFNO=1
//FT15F001 DD DDNAME=OBSCARDS     OBSERVATION CARDS
//FT16F001 DD UNIT=DISK,          DATA SIMULATION SUMMARY WORKING FILE
//             SPACE=(TRK,(1,6)),DCB=(RECFM=VBS,LRECL=124,BLKSIZE=3352,
//             DSORG=DA,BUFNO=1)
//FT17F001 DD UNIT=DISK,          OBSERVATIONS WORKING FILE
//             SPACE=(CYL,4),DCB=(DSORG=DA,BUFNO=1)
//FT18F001 DD UNIT=DISK,          SLP WORKING FILE
//             SPACE=(3520,12),DCB=(DSORG=DA,BUFNO=1)
//FT19F001 DD DUMMY,              DISK ORBIT FILE WITH PARTIALS
//             UNIT=DISK,DCB=(RECFM=F,BLKSIZE=6660,DSORG=DA,BUFNO=1),
//             SPACE=(6660,240)
//FT20F001 DD DUMMY,              DISK ORBIT FILE WITHOUT PARTIALS
//             UNIT=DISK,DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1),
//             SPACE=(1092,240)
//FT21F001 DD DUMMY,              TAPE ORBIT FILE WITH PARTIALS
//             UNIT=9TRACK,DCB=(RECFM=VS,LRECL=6664,BLKSIZE=6668,
//             BUFNO=1),LABEL=(,BLP),DISP=SHR
//FT22F001 DD DUMMY,              TAPE ORBIT FILE WITHOUT PARTIALS
//             UNIT=9TRACK,DCB=(RECFM=VS,LRECL=1096,BLKSIZE=1100,
//             BUFNO=1),LABEL=(,BLP),DISP=SHR
//FT23F001 DD &GRAPH.UNIT=DISK,   ERROR MESSAGES FOR SCOPE
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,
//             BUFNO=1)
//FT24F001 DD UNIT=DISK,          1ST ORBI OR EPHEM OUTPUT FILE
//             SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)
//FT25F001 DD DISP=SHR,DSN=GJFEM.GTDS.ELEMENTS.DATA,DCB=BUFNO=1
//FT26F001 DD DISP=SHR,DSN=GJFEM.GTDS.D24HOUR.DATA,DCB=BUFNO=1
//FT27F001 DD DISP=SHR,DSN=GJFEM.GTDS.GEODTICS.DATA,DCB=BUFNO=1
//FT28F001 DD &GRAPH.UNIT=DISK,   SATELLITE EPHEMERIS TO SCOPE
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,BUFNO=1),
//             SPACE=(TRK,(1,20))
```

```
//FT29F001 DD DUMMY,                GTDS OBSERVATION TAPE FILE               JCL 110
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408,            JCL 112
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                                JCL 114
//FT30F001 DD DUMMY,                DODS OBSERVATION TAPE                    JCL 116
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044,            JCL 118
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                                JCL 120
//FT31F001 DD DUMMY,                GTDS OBSERVATION DISK FILE               JCL 122
//             UNIT=DISK,DISP=SHR                                            JCL 124
//FT32F001 DD DISP=SHR,DSN=GRKEL.POBS.DATA       DODS OBSERVATIONS           JCL 126
//FT33F001 DD DUMMY,                SLP TAPE                                 JCL 128
//             UNIT=9TRACK,DCB=(RECFM=VS,BLKSIZE=3460,BUFNO=1),              JCL 130
//             LABEL=(,BLP),DISP=SHR                                         JCL 132
//FT34F001 DD DUMMY,                JPL TAPE                                 JCL 134
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=8304,BLKSIZE=8308,           JCL 136
//             BUFNO=1,DEN=2),LABEL=(,BLP,,IN),DISP=SHR                      JCL 138
//FT35F001 DD &GRAPH.UNIT=DISK,   INTEGRATION STATISTICS FOR SCOPE           JCL 140
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,       JCL 142
//             BUFNO=1)                                                      JCL 144
//FT36F001 DD &GRAPH.UNIT=DISK,   FINAL ORBIT GENERATOR DISPLAY FOR SCOP     JCL 146
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,       JCL 148
//             BUFNO=1)                                                      JCL 150
//FT37F001 DD &SORT.UNIT=DISK,    OBSERVATIONS SORT FILE                     JCL 152
//             DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408,BUFNO=1),               JCL 154
//             SPACE=(CYL,(2,1))                                             JCL 156
//FT38F001 DD DSN=GJFEM.GTDS.TIMCOF.DATA,DISP=SHR                            JCL 158
//FT39F001 DD DISP=SHR,DSN=GJFEM.GTDS.GENCOF.DATA,DCB=BUFNO=1                JCL 160
//FT40F001 DD DUMMY                PERMANENT FILES TO SCOPE                  JCL 162
//FT41F001 DD UNIT=DISK,           TEMPORARY STARTER ARRAYS                  JCL 164
//             SPACE=(TRK,(1,10)),DCB=(RECFM=VBS,LRECL=1452,BUFNO=1,         JCL 166
//             BLKSIZE=7264)                                                 JCL 168
//FT42F001 DD &GRAPH.UNIT=DISK,   OBSERVATION RESIDUALS FOR SCOPE            JCL 170
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,       JCL 172
//             BUFNO=1)                                                      JCL 174
//FT43F001 DD &GRAPH.UNIT=DISK,   SOLVE PARAMETERS FOR SCOPE                 JCL 176
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,       JCL 178
//             BUFNO=1)                                                      JCL 180
//FT44F001 DD &GRAPH.UNIT=DISK,   ELEMENTS FOR SCOPE                         JCL 182
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,       JCL 184
//             BUFNO=1)                                                      JCL 186
//FT45F001 DD UNIT=DISK,          OBSERVATIONS WORKING FILE HEADER           JCL 188
//             SPACE=(TRK,(1,1)),DCB=(RECFM=VS,BLKSIZE=928,BUFNO=1),         JCL 190
//             VOL=REF=*.FT17F001  SAME VOLUME AS THE WORKING FILE           JCL 192
//FT46F001 DD LABEL=(2,BLP),      GTDS OBSERVATION TAPE HEADER               JCL 194
//             DCB=(RECFM=VS,BLKSIZE=928,BUFNO=1),DISP=SHR,                  JCL 196
//             VOL=REF=*.FT29F001  SAME VOLUME AS GTDS TAPE                  JCL 198
//FT47F001 DD UNIT=DISK,DISP=SHR, GTDS OBSERVATIONS DISK HEADER              JCL 200
//             VOL=REF=*.FT31F001  SAME VOLUME AS GTDS DISK OBSERVATIONS     JCL 202
//FT48F001 DD &SORT.UNIT=DISK,  OBSERVATIONS SORT FILE HEADER                JCL 204
//             DCB=(RECFM=VS,BLKSIZE=928,BUFNO=1),                           JCL 206
//             SPACE=(TRK,(5,1))   SAME VOLUME AS OBSERVATION SORT FILE      JCL 208
//FT49F001 DD &GRAPH.UNIT=DISK,   D. C. SUMMARY REPORT FOR SCOPE             JCL 210
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,       JCL 212
//             BUFNO=1)                                                      JCL 214
//FT50F001 DD DDNAME=DODSUM        TRACKING DATA ACQUISITION SUMMARY         JCL 216
//FT51F001 DD DUMMY,UNIT=9TRACK,   TELETYPE ELEMENTS REPORT                  JCL 218
//    LABEL=(,BLP),DCB=(RECFM=FBA,LRECL=80,BLKSIZE=800,BUFNO=1),             JCL 220
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//              DISP=SHR                                                 JCL 222
//FT52F001 DD DUMMY,               DATA SIMULATION INPUT DODS TAPE       JCL 224
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044,        JCL 226
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                            JCL 228
//FT53F001 DD DUMMY,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),UNIT=2314,       JCL 230
//             DISP=SHR                                                  JCL 232
//FT54F001 DD DUMMY,  CHEBYSHEV EPHEMERIS FOR PDP-11                     JCL 234
//             UNIT=9TRACK,LABEL=(1,BLP),                                JCL 236
//             DCB=(RECFM=FB,LRECL=316,BLKSIZE=316,DEN=2,BUFNO=1)        JCL 238
//FT55F001 DD &GRAPH.UNIT=&UNIT   GRAPHICS DEVICE  (2250)                JCL 240
//FT56F001 DD DUMMY,               STADAN OBSERVATION TAPE               JCL 242
//             UNIT=9TRACK,DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=2,    JCL 244
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                            JCL 246
//FT57F001 DD UNIT=DISK,           SCRATCH AREA FOR COMMON               JCL 248
//             SPACE=(TRK,(1,10)),DISP=(NEW,DELETE),DCB=BUFNO=1          JCL 250
//FT58F001 DD UNIT=2314,           IONOSPHERE WORKING FILE               JCL 252
//             SPACE=(1332,20),DCB=(DSORG=DA,BUFNO=1),DSN=&&WIONO        JCL 254
//FT59F001 DD DISP=SHR,DSN=GJFEM.GTDS.SOLDAT.DATA,DCB=BUFNO=1            JCL 256
//FT60F001 DD DISP=SHR,DSN=GJFEM.GTDS.ACCOUNT.DATA,DCB=BUFNO=1           JCL 258
//FT63F001 DD DUMMY,DCB=DSORG=DA                                         JCL 260
//FT64F001 DD DISP=SHR,            DODS ELEMENTS                         JCL 262
//             DSN=GRKEL.PELS.DATA                                       JCL 264
//FT65F001 DD UNIT=2314,           IONOSPHERE WORKING FILE               JCL 266
//             SPACE=(TRK,(1,20),RLSE),DCB=(DSORG=DA,BUFNO=1),           JCL 268
//             DSN=&&IONDAT                                              JCL 270
//FT66F001 DD DUMMY,               REAL TIME IONOSPHERE DATA             JCL 272
//             UNIT=2314,SPACE=(TRK,(1,20)),DCB=BUFNO=1                  JCL 274
//FT67F001 DD DUMMY,               REAL TIME IONOSPHERE DATA             JCL 276
//             UNIT=2314,SPACE=(1416,151),DCB=(DSORG=DA,BUFNO=1)         JCL 278
//FT68F001 DD DISP=SHR,DSN=GJFEM.GTDS.TRODAT.DATA,DCB=BUFNO=1            JCL 280
//FT70F001 DD DUMMY,UNIT=2314,DISP=SHR                                   JCL 282
//FT75F001 DD DISP=SHR,DSN=GJFEM.GTDS.JACCHIA.DATA                       JCL 284
//FT77F001 DD UNIT=DISK,           EPHEM WORKING FILE                    JCL 286
//             SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)    JCL 288
//FT78F001 DD  DUMMY,               DODS PERM OBSERVATIONS               JCL 290
//              DISP=SHR,DCB=BUFNO=1,                                    JCL 292
//              DSN=GRKEL.DODS.DATA.POBSDC.DATA                          JCL 294
//FT81F001 DD UNIT=DISK,           2ND ORB1 OR EPHEM OUTPUT FILE         JCL 296
//             SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)    JCL 298
//FT82F001 DD DUMMY,               COMPARE SEQ ORBIT FILE 2, WITH PARTS  JCL 300
//             UNIT=9TRACK,DCB=(RECFM=VS,LRECL=6664,BLKSIZE=6668,        JCL 302
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                            JCL 304
//FT83F001 DD UNIT=DISK,           3RD ORB1 OR EPHEM OUTPUT FILE         JCL 306
//             SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)    JCL 308
//FT84F001 DD DUMMY,               COMPARE SEQ ORBIT FILE 2, W/O PARTS   JCL 310
//             UNIT=9TRACK,DCB=(RECFM=VS,LRECL=1096,BLKSIZE=1100,        JCL 312
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                            JCL 314
//FT85F001 DD UNIT=DISK,           4TH ORB1 OR EPHEM OUTPUT FILE         JCL 316
//             SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)    JCL 318
//FT86F001 DD DUMMY,               COMPARE DA ORBIT FILE 2, WITH PARTS   JCL 320
//             UNIT=DISK,DCB=(RECFM=F,BLKSIZE=6660,DSORG=DA,BUFNO=1),    JCL 322
//             SPACE=(6660,240)                                          JCL 324
//FT87F001 DD UNIT=DISK,           5TH ORB1 OR EPHEM OUTPUT FILE         JCL 326
//             SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)    JCL 328
//FT88F001 DD DUMMY,               COMPARE DA ORBIT FILE 2, W/O PARTIALS JCL 330
//             UNIT=DISK,DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1),    JCL 332
//             SPACE=(1092,240)                                          JCL 334
//FT91F001 DD DUMMY,               USB OBSERVATIONS (72-BYTE)            JCL 336
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=76,BLKSIZE=5248),        JCL 338
//             DISP=SHR                                                  JCL 340
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//FT97F001 DD DUMMY,DCB=(RECFM=FB,LRECL=80,BLKSIZE=80)                  JCL 342
//INPUTPDS DD DUMMY,                CRT INPUT                           JCL 344
//             UNIT=2314,DISP=SHR                                       JCL 346
//NUCLEUS DD DISP=SHR,VOL=REF=SYS1.SVCLIB,DCB=BUFNO=1                   JCL 348
//SYSUDUMP DD SYSOUT=A,SPACE=(TRK,10)                                   JCL 350
//ERRDUMP  DD &GRAPH.SYSOUT=A,SPACE=(CYL,(1,1))                         JCL 352
//UCLEG  PROC  SORT='DUMMY,',GRAPH='DUMMY,',UNIT=2250                   JCL 354
//PDSUP EXEC PGM=MACTS,REGION=84K                                       JCL 356
//**********************                                  FEM/28JUN74   JCL 358
//STEPLIB DD DSN=GJFEM.GTDS.UPDATE.LOAD,DISP=SHR                        JCL 360
//SYSPRINT DD SYSOUT=A                                                  JCL 362
//SYSIN    DD DDNAME=DATA5                                              JCL 364
//PDSIN DD DSN=GJFEM.GTDS.SORSLIB.FORT,DISP=SHR                         JCL 366
//SEQOUT   DD DSN=&SCR,UNIT=DISK,SPACE=(CYL,(5,1),RLSE),DISP=(MOD,PASS) JCL 368
//SUBRLIST DD SYSOUT=A,SPACE=(CYL,(0,5),RLSE),UNIT=(DISK,3)             JCL 370
//SOURCE EXEC PGM=IEKAA00,PARM='XREF,OPT=2',REGION=300K                 JCL 372
//SYSLIN DD DSN=&&OBJMOD,UNIT=DISK,SPACE=(CYL,(1,1)),                   JCL 374
//             DISP=(MOD,PASS),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)     JCL 376
//SYSTERM  DD  SYSOUT=A                                                 JCL 378
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),          JCL 380
//             SPACE=(CYL,(4,2),RLSE)                                   JCL 382
//SYSPUNCH DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200),            JCL 384
//             SPACE=(TRK,(0,5),RLSE)                                   JCL 386
//SYSUT1   DD UNIT=DISK,SPACE=(CYL,(1,1))                               JCL 388
//SYSUT2   DD UNIT=DISK,SPACE=(CYL,(1,1))                               JCL 390
//SYSIN    DD DSN=&SCR,UNIT=2314,DISP=(OLD,DELETE)                      JCL 392
//LINK EXEC PGM=IEWL,PARM='LET,LIST,MAP,OVLY,SIZE=(240K,48K)',          JCL 394
//        COND=(5,LT),REGION=250K                                       JCL 396
//LOADLIB  DD DUMMY                                                     JCL 398
//NEWLIN   DD DUMMY                                                     JCL 400
//SYSLIB   DD DSN=SYS2.DUMMY,DISP=SHR                                   JCL 402
//         DD DSN=SYS2.DUMMY,DISP=SHR                                   JCL 404
//         DD DSN=GJFEM.GTDS.LOADMOD.LOAD,DISP=SHR                      JCL 406
//         DD DSN=SYS1.FORTLIB,DISP=SHR                                 JCL 408
//         DD DSN=SYS2.GSFCLIB,DISP=SHR                                 JCL 410
//         DD DSN=SYS1.PL1LIB,DISP=SHR                                  JCL 412
//SYSLMOD  DD DSN=&&LODMOD(GTDSTEMP),DISP=(,PASS),                      JCL 414
//             SPACE=(CYL,(17,1,1),RLSE),UNIT=DISK                      JCL 416
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=121,BLKSIZE=1210),          JCL 418
//              SPACE=(CYL,(2,1))                                       JCL 420
//SYSUT1 DD UNIT=(DISK,3),SPACE=(CYL,(17,1))                            JCL 422
//SYSUDUMP DD SYSOUT=A                                                  JCL 424
//TAPELIB  DD DUMMY,DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)                JCL 426
//SYSLIN   DD DSN=&&OBJMOD,DISP=(OLD,DELETE),DCB=RECFM=FB               JCL 428
//         DD  DSN=GJFEM.GTDS.OVERLAY.DATA,DISP=SHR                     JCL 430
//         DD DDNAME=OBJECT                                             JCL 432
//GO  EXEC  PGM=*.LINK.SYSLMOD,COND=((5,LT,SOURCE),EVEN),REGION=490K    JCL 434
//FT01F001 DD DISP=SHR,DSN=GJFEM.GTDS.DIRECTRY.DATA,DCB=BUFNO=1         JCL 436
//FT02F001 DD DISP=SHR,DSN=GJFEM.GTDS.ATMOSDEN.DATA,DCB=BUFNO=1         JCL 438
//FT03F001 DD DISP=SHR,DSN=GJFEM.GTDS.MANEUVER.DATA,DCB=BUFNO=1         JCL 440
//FT04F001 DD DISP=SHR,DSN=GJFEM.GTDS.ASTROCON.DATA,DCB=BUFNO=1         JCL 442
//FT05F001 DD DDNAME=DATA5                                              JCL 444
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=7265),          JCL 446
//             SPACE=(CYL,(3,1),RLSE)                                   JCL 448
//FT07F001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800,BUFNO=1)      JCL 450
//FT08F001 DD DISP=SHR,DSN=GJFEM.GTDS.EARTHFLD.DATA,DCB=BUFNO=1         JCL 452
//FT09F001 DD DISP=SHR,DSN=GJFEM.GTDS.LUNARFLD.DATA,DCB=BUFNO=1         JCL 454
//FT10F001 DD DISP=SHR,DSN=GJFEM.GTDS.INTCOEF.DATA,DCB=BUFNO=1          JCL 456
//FT11F001 DD DISP=SHR,DSN=GJFEM.GTDS.SECTIONS.DATA,DCB=BUFNO=1         JCL 458
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//FT12F001 DD &GRAPH.UNIT=DISK,   TEMPORARY DATA FOR CRT INPUT MODE        JCL 460
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=2000,BUFNO=1),                JCL 462
//             DISP=(NEW,DELETE),SPACE=(TRK,(1,1)),DSN=&&INPROMPT           JCL 464
//FT13F001 DD DISP=SHR,DSN=GJFEM.GTDS.ERRORMSG.DATA,DCB=BUFNO=1             JCL 466
//FT14F001 DD DISP=SHR,DSN=GJFEM.GTDS.SLP1950.DATA,                         JCL 468
//             LABEL=(,,,IN),DCB=BUFNO=1                                    JCL 470
//FT15F001 DD DDNAME=OBSCARDS      OBSERVATION CARDS                        JCL 472
//FT16F001 DD UNIT=DISK,           DATA SIMULATION SUMMARY WORKING FILE     JCL 474
//             SPACE=(TRK,(1,6)),DCB=(RECFM=VBS,LRECL=124,BLKSIZE=3352,     JCL 476
//             DSORG=DA,BUFNO=1)                                            JCL 478
//FT17F001 DD UNIT=DISK,           OBSERVATIONS WORKING FILE                JCL 480
//             SPACE=(CYL,4),DCB=(DSORG=DA,BUFNO=1)                         JCL 482
//FT18F001 DD UNIT=DISK,           SLP WORKING FILE                         JCL 484
//             SPACE=(3520,12),DCB=(DSORG=DA,BUFNO=1)                       JCL 486
//FT19F001 DD DUMMY,               DISK ORBIT FILE WITH PARTIALS            JCL 488
//             UNIT=DISK,DCB=(RECFM=F,BLKSIZE=6660,DSORG=DA,BUFNO=1),       JCL 490
//             SPACE=(6660,240)                                             JCL 492
//FT20F001 DD DUMMY,               DISK ORBIT FILE WITHOUT PARTIALS         JCL 494
//             UNIT=DISK,DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1),       JCL 496
//             SPACE=(1092,240)                                             JCL 498
//FT21F001 DD DUMMY,               TAPE ORBIT FILE WITH PARTIALS            JCL 500
//             UNIT=9TRACK,DCB=(RECFM=VS,LRECL=6664,BLKSIZE=6668,           JCL 502
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                               JCL 504
//FT22F001 DD DUMMY,               TAPE ORBIT FILE WITHOUT PARTIALS         JCL 506
//             UNIT=9TRACK,DCB=(RECFM=VS,LRECL=1096,BLKSIZE=1100,           JCL 508
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                               JCL 510
//FT23F001 DD &GRAPH.UNIT=DISK,   ERROR MESSAGES FOR SCOPE                 JCL 512
//             SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,      JCL 514
//             BUFNO=1)                                                     JCL 516
//FT24F001 DD UNIT=DISK,           1ST ORB1 OR EPHEM OUTPUT FILE            JCL 518
//             SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)       JCL 520
//FT25F001 DD DISP=SHR,DSN=GJFEM.GTDS.ELEMENTS.DATA,DCB=BUFNO=1             JCL 522
//FT26F001 DD DISP=SHR,DSN=GJFEM.GTDS.D24HOUR.DATA,DCB=BUFNO=1              JCL 524
//FT27F001 DD DISP=SHR,DSN=GJFEM.GTDS.GEODTICS.DATA,DCB=BUFNO=1             JCL 526
//FT28F001 DD &GRAPH.UNIT=DISK,   SATELLITE EPHEMERIS TO SCOPE             JCL 528
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,BUFNO=1),                JCL 530
//             SPACE=(TRK,(1,20))                                           JCL 532
//FT29F001 DD DUMMY,               GTDS OBSERVATION TAPE FILE               JCL 534
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408,           JCL 536
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                               JCL 538
//FT30F001 DD DUMMY,               DODS OBSERVATION TAPE                    JCL 540
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044,           JCL 542
//             BUFNO=1),LABEL=(,BLP),DISP=SHR                               JCL 544
//FT31F001 DD DUMMY,               GTDS OBSERVATION DISK FILE               JCL 546
//             UNIT=DISK,DISP=SHR                                           JCL 548
//FT32F001 DD DISP=SHR,DSN=GRKEL.POBS.DATA                                  JCL 550
//FT33F001 DD DUMMY,               SLP TAPE                                 JCL 552
//             UNIT=9TRACK,DCB=(RECFM=VS,BLKSIZE=3460,BUFNO=1),             JCL 554
//             LABEL=(,BLP),DISP=SHR                                        JCL 556
//FT34F001 DD DUMMY,               JPL TAPE                                 JCL 558
//             UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=8304,BLKSIZE=8308,          JCL 560
//             BUFNO=1,DEN=2),LABEL=(,BLP,,IN),DISP=SHR                     JCL 562
//FT35F001 DD &GRAPH.UNIT=DISK,   INTEGRATION STATISTICS FOR SCOPE         JCL 564
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//FT12F001 DD &GRAPH.UNIT=DISK,   TEMPORARY DATA FOR CRT INPUT MODE
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=2000,BUFNO=1),
//            DISP=(NEW,DELETE),SPACE=(TRK,(1,1)),DSN=&&INPROMPT
//FT13F001 DD DISP=SHR,DSN=GJFEM.GTDS.ERRORMSG.DATA,DCB=BUFNO=1
//FT14F001 DD DISP=SHR,DSN=GJFEM.GTDS.SLP1950.DATA,
//            LABEL=(,,,IN),DCB=BUFNO=1
//FT15F001 DD DDNAME=OBSCARDS        OBSERVATION CARDS
//FT16F001 DD UNIT=DISK,             DATA SIMULATION SUMMARY WORKING FILE
//            SPACE=(TRK,(1,6)),DCB=(RECFM=VBS,LRECL=124,BLKSIZE=3352,
//            DSORG=DA,BUFNO=1)
//FT17F001 DD UNIT=DISK,             OBSERVATIONS WORKING FILE
//            SPACE=(CYL,4),DCB=(DSORG=DA,BUFNO=1)
//FT18F001 DD UNIT=DISK,             SLP WORKING FILE
//            SPACE=(3520,12),DCB=(DSORG=DA,BUFNO=1)
//FT19F001 DD DUMMY,                 DISK ORBIT FILE WITH PARTIALS
//            UNIT=DISK,DCB=(RECFM=F,BLKSIZE=6660,DSORG=DA,BUFNO=1),
//            SPACE=(6660,240)
//FT20F001 DD DUMMY,                 DISK ORBIT FILE WITHOUT PARTIALS
//            UNIT=DISK,DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1),
//            SPACE=(1092,240)
//FT21F001 DD DUMMY,                 TAPE ORBIT FILE WITH PARTIALS
//            UNIT=9TRACK,DCB=(RECFM=VS,LRECL=6664,BLKSIZE=6668,
//            BUFNO=1),LABEL=(,BLP),DISP=SHR
//FT22F001 DD DUMMY,                 TAPE ORBIT FILE WITHOUT PARTIALS
//            UNIT=9TRACK,DCB=(RECFM=VS,LRECL=1096,BLKSIZE=1100,
//            BUFNO=1),LABEL=(,BLP),DISP=SHR
//FT23F001 DD &GRAPH.UNIT=DISK,   ERROR MESSAGES FOR SCOPE
//            SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,
//            BUFNO=1)
//FT24F001 DD UNIT=DISK,             1ST ORB1 OR EPHEM OUTPUT FILE
//            SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)
//FT25F001 DD DISP=SHR,DSN=GJFEM.GTDS.ELEMENTS.DATA,DCB=BUFNO=1
//FT26F001 DD DISP=SHR,DSN=GJFEM.GTDS.D24HOUR.DATA,DCB=BUFNO=1
//FT27F001 DD DISP=SHR,DSN=GJFEM.GTDS.GEODTICS.DATA,DCB=BUFNO=1
//FT28F001 DD &GRAPH.UNIT=DISK,   SATELLITE EPHEMERIS TO SCOPE
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,BUFNO=1),
//            SPACE=(TRK,(1,20))
//FT29F001 DD DUMMY,                 GTDS OBSERVATION TAPE FILE
//            UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408,
//            BUFNO=1),LABEL=(,BLP),DISP=SHR
//FT30F001 DD DUMMY,                 DODS OBSERVATION TAPE
//            UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044,
//            BUFNO=1),LABEL=(,BLP),DISP=SHR
//FT31F001 DD DUMMY,                 GTDS OBSERVATION DISK FILE
//            UNIT=DISK,DISP=SHR
//FT32F001 DD DISP=SHR,DSN=GRKEL.POBS.DATA
//FT33F001 DD DUMMY,                 SLP TAPE
//            UNIT=9TRACK,DCB=(RECFM=VS,BLKSIZE=3460,BUFNO=1),
//            LABEL=(,BLP),DISP=SHR
//FT34F001 DD DUMMY,                 JPL TAPE
//            UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=8304,BLKSIZE=8308,
//            BUFNO=1,DEN=2),LABEL=(,BLP,,IN),DISP=SHR
//FT35F001 DD &GRAPH.UNIT=DISK,   INTEGRATION STATISTICS FOR SCOPE
//            SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,
//            BUFNO=1)
//FT36F001 DD &GRAPH.UNIT=DISK,   FINAL ORBIT GENERATOR DISPLAY FOR SCOP
//            SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,
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//           BUFNO=1)                                                  JCL 574
//FT37F001 DD &SORT.UNIT=DISK,    OBSERVATIONS SORT FILE               JCL 576
//           DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408,BUFNO=1),           JCL 578
//           SPACE=(CYL,(2,1))                                         JCL 580
//FT38F001 DD DSN=GJFEM.GTDS.TIMCOF.DATA,DISP=SHR                      JCL 582
//FT39F001 DD DISP=SHR,DSN=GJFEM.GTDS.GENCOF.DATA,DCB=BUFNO=1          JCL 584
//FT40F001 DD DUMMY               PERMANENT FILES TO SCOPE             JCL 586
//FT41F001 DD UNIT=DISK,          TEMPORARY STARTER ARRAYS             JCL 588
//           SPACE=(TRK,(1,10)),DCB=(RECFM=VBS,LRECL=1452,BUFNO=1,     JCL 590
//           BLKSIZE=7264)                                             JCL 592
//FT42F001 DD &GRAPH.UNIT=DISK,   OBSERVATION RESIDUALS FOR SCOPE      JCL 594
//           SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,   JCL 596
//           BUFNO=1)                                                  JCL 598
//FT43F001 DD &GRAPH.UNIT=DISK,   SOLVE PARAMETERS FOR SCOPE           JCL 600
//           SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,   JCL 602
//           BUFNO=1)                                                  JCL 604
//FT44F001 DD &GRAPH.UNIT=DISK,   ELEMENTS FOR SCOPE                   JCL 606
//           SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,   JCL 608
//           BUFNO=1)                                                  JCL 610
//FT45F001 DD UNIT=DISK,          OBSERVATIONS WORKING FILE HEADER     JCL 612
//           SPACE=(TRK,(1,1)),DCB=(RECFM=VS,BLKSIZE=928,BUFNO=1),     JCL 614
//           VOL=REF=*.FT17F001   SAME VOLUME AS THE WORKING FILE      JCL 616
//FT46F001 DD LABEL=(2,BLP),      GTDS OBSERVATION TAPE HEADER         JCL 618
//           DCB=(RECFM=VS,BLKSIZE=928,BUFNO=1),DISP=SHR,              JCL 620
//           VOL=REF=*.FT29F001   SAME VOLUME AS GTDS TAPE             JCL 622
//FT47F001 DD UNIT=DISK.DISP=SHR, GTDS OBSERVATIONS DISK HEADER        JCL 624
//           VOL=REF=*.FT31F001   SAME VOLUME AS GTDS DISK OBSERVATIONS JCL 626
//FT48F001 DD &SORT.UNIT=DISK,  OBSERVATIONS SORT FILE HEADER          JCL 628
//           DCB=(RECFM=VS,BLKSIZE=928,BUFNO=1),                       JCL 630
//           SPACE=(TRK,(5,1))    SAME VOLUME AS OBSERVATION SORT FILE JCL 632
//FT49F001 DD &GRAPH.UNIT=DISK,   D. C. SUMMARY REPORT FOR SCOPE       JCL 634
//           SPACE=(TRK,(1,20)),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200,   JCL 636
//           BUFNO=1)                                                  JCL 638
//FT50F001 DD DDNAME=DODSUM       TRACKING DATA ACQUISITION SUMMARY    JCL 640
//FT51F001 DD DUMMY,UNIT=9TRACK,  TELETYPE ELEMENTS REPORT             JCL 642
//   LABEL=(,BLP),DCB=(RECFM=FBA,LRECL=80,BLKSIZE=800,BUFNO=1),        JCL 644
//            DISP=SHR                                                 JCL 646
//FT52F001 DD DUMMY,              DATA SIMULATION INPUT DODS TAPE      JCL 648
//           UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=104,BLKSIZE=1044,        JCL 650
//           BUFNO=1),LABEL=(,BLP),DISP=SHR                            JCL 652
//FT53F001 DD DUMMY,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),UNIT=2314,     JCL 654
//           DISP=SHR                                                  JCL 656
//FT54F001 DD DUMMY,  CHEBYSHEV EPHEMERIS FOR PDP-11                   JCL 658
//           UNIT=9TRACK,LABEL=(1,BLP),                                JCL 660
//           DCB=(RECFM=FB,LRECL=316,BLKSIZE=316,DEN=2,BUFNO=1)        JCL 662
//FT55F001 DD &GRAPH.UNIT=&UNIT   GRAPHICS DEVICE  (2250)              JCL 664
//FT56F001 DD DUMMY,              STADAN OBSERVATION TAPE              JCL 666
//           UNIT=9TRACK,DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=2,    JCL 668
//           BUFNO=1),LABEL=(,BLP),DISP=SHR                            JCL 670
//FT57F001 DD UNIT=DISK,          SCRATCH AREA FOR COMMON              JCL 672
//           SPACE=(TRK,(1,10)),DISP=(NEW,DELETE),DCB=BUFNO=1          JCL 674
//FT58F001 DD UNIT=2314,          IONOSPHERE WORKING FILE              JCL 676
//           SPACE=(1332,20),DCB=(DSORG=DA,BUFNO=1),DSN=&&WIONO         JCL 678
//FT59F001 DD DISP=SHR,DSN=GJFEM.GTDS.SOLDAT.DATA,DCB=BUFNO=1          JCL 680
//FT60F001 DD DISP=SHR,DSN=GJFEM.GTDS.ACCOUNT.DATA,DCB=BUFNO=1         JCL 682
//FT63F001 DD DUMMY,DCB=DSORG=DA                                       JCL 684
//FT64F001 DD DISP=SHR,DSN=GRKEL.PELS.DATA    DODS ELEMENTS            JCL 686
//FT65F001 DD UNIT=2314,          IONOSPHERE WORKING FILE              JCL 688
```

```
//              SPACE=(TRK,(1,20),RLSE),DCB=(DSORG=DA,BUFNO=1),              JCL 690
//              DSN=&&IONDAT                                                 JCL 692
//FT66F001 DD DUMMY,              REAL TIME IONOSPHERE DATA                  JCL 694
//              UNIT=2314,SPACE=(TRK,(1,20)),DCB=BUFNO=1                     JCL 696
//FT67F001 DD DUMMY,              REAL TIME IONOSPHERE DATA                  JCL 698
//              UNIT=2314,SPACE=(1416,151),DCB=(DSORG=DA,BUFNO=1)            JCL 700
//FT68F001 DD DISP=SHR,DSN=GJFEM.GTDS.TRODAT.DATA,DCB=BUFNO=1                JCL 702
//FT70F001 DD DUMMY,UNIT=2314,DISP=SHR                                       JCL 704
//FT75F001 DD DISP=SHR,DSN=GJFEM.GTDS.JACCHIA.DATA                           JCL 706
//FT77F001 DD UNIT=DISK,          EPHEM WORKING FILE                         JCL 708
//              SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)       JCL 710
//FT78F001 DD  DUMMY,UNIT=(2321,3),                                          JCL 712
//               DISP=SHR,DCB=BUFNO=1,                                       JCL 714
//               DSN=GRKEL.DODS.DATA.POBSDC.DATA                             JCL 716
//FT81F001 DD UNIT=DISK,          2ND ORB1 OR EPHEM OUTPUT FILE              JCL 718
//              SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)       JCL 720
//FT82F001 DD DUMMY,              COMPARE SEQ ORBIT FILE 2, WITH PARTS       JCL 722
//              UNIT=9TRACK,DCB=(RECFM=VS,LRECL=6664,BLKSIZE=6668,           JCL 724
//              BUFNO=1),LABEL=(,BLP),DISP=SHR                               JCL 726
//FT83F001 DD UNIT=DISK,          3RD ORB1 OR EPHEM OUTPUT FILE              JCL 728
//              SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)       JCL 730
//FT84F001 DD DUMMY,              COMPARE SEQ ORBIT FILE 2, W/O PARTS        JCL 732
//              UNIT=9TRACK,DCB=(RECFM=VS,LRECL=1096,BLKSIZE=1100,           JCL 734
//              BUFNO=1),LABEL=(,BLP),DISP=SHR                               JCL 736
//FT85F001 DD UNIT=DISK,          4TH ORB1 OR EPHEM OUTPUT FILE              JCL 738
//              SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)       JCL 740
//FT86F001 DD DUMMY,              COMPARE DA ORBIT FILE 2, WITH PARTS        JCL 742
//              UNIT=DISK,DCB=(RECFM=F,BLKSIZE=6660,DSORG=DA,BUFNO=1),       JCL 744
//              SPACE=(6660,240)                                             JCL 746
//FT87F001 DD UNIT=DISK,          5TH ORB1 OR EPHEM OUTPUT FILE              JCL 748
//              SPACE=(TRK,(1,20)),DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)       JCL 750
//FT88F001 DD DUMMY,              COMPARE DA ORBIT FILE 2, W/O PARTIALS      JCL 752
//              UNIT=DISK,DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1),       JCL 754
//              SPACE=(1092,240)                                             JCL 756
//FT91F001 DD DUMMY,              USB OBSERVATIONS (72-BYTE)                 JCL 758
//              UNIT=9TRACK,DCB=(RECFM=VBS,LRECL=76,BLKSIZE=5248),           JCL 760
//              DISP=SHR                                                     JCL 762
//FT97F001 DD DUMMY,DCB=(RECFM=FB,LRECL=80,BLKSIZE=80)                       JCL 764
//INPUTPDS DD DUMMY,              CRT INPUT                                  JCL 766
//              UNIT=2314,DISP=SHR                                           JCL 768
//NUCLEUS DD DISP=SHR,VOL=REF=SYS1.SVCLIB,DCB=BUFNO=1                        JCL 770
//SYSOUT   DD &SORT.SYSOUT=A                                 >   IBM         JCL 772
//SYSUDUMP DD SYSOUT=A,SPACE=(TRK,10)                                        JCL 774
//ERRDUMP  DD &GRAPH.SYSOUT=A,SPACE=(CYL,(1,1))                              JCL 776
```

```
//       (8000,5000),CLASS=D
//STEP1  EXEC  PROC=FORTRANG,PARM='MAP,ID',TIME,CMP=(0,15)
//CMP.SYSIN  DD  *
C     VERSION OF JAN. 27,1974
C     PURPOSE
C         TO PROVIDE AN EXECUTIVE PROGRAM FOR CONTROL OF THE
C         GTDS ORBIT DETERMINATION SUBSYSTEM
C     CALLING SEQUENCE
C         NONE
C     SUBROUTINES CALLED
C         SETDAF,RUNACC,SETRUN,CRTIN,WFCONT,DC,EPHGEN,DSPEXC,SELKUN,EO
C
C     COMMON BLOCK VARIABLES
C         IEOF  =  END-OF-FILE FLAG
C         IPRMPT= CRT INPUT MODE INDICATOR(1=YES, 2=NO)
C         IND48 =  TYPE RUN INDICATOR
C                   1= DIFFERENTIAL CORRECTION
C                   2= ORBIT GENERATOR
C                   3= DATA SIMULATION
C                   4= ORBIT COMPARE
C                   5= DATA MANAGEMENT
C                   6= PERMANENT FILE REPORT
C                   7= ERROR ANALYSIS
C         ITYPE =  0 FOR AN ODS RUN
C               =  1 FOR A PERMANENT FILE MAINTENANCE RUN
C         NBRDC =  NUMBER OF CURRENT D.C. RUN
C         NBRRUN=  NUMBER OF CURRENT RUN
C     NOPTS =  THE FRN OF THE OPTIONS INPUT DATA SET
C         NOUT  =  THE FRN OF THE PRINTER OUTPUT
C         IEXCNT=  EXECUTIVE CONTINUATION INDICATOR (1=YES ,2=NO)
C         IPASWD= PASSWORD OF NBTST FILE
C         ITSTR = NBTST RECORD NUMBER TO USE
C         NBNOM = FRN OF NOMINAL BENCHMARK CASES
C         NBTST = FRN OF TEST BENCHMARK CASES
C
C     REFERENCE
C         GTDS TASK SPEC. 'ODS EXECUTIVE CONTROL(MAIN)' BY J. E. DUNN
C     PROGRAMMER
C         M. A. WELKER - COMPUTER SCIENCES CORPORATION
C
C     PROGRAM MODIFICATIONS
C         04/10/72 W.N. WESTON, GSFC
C           (A) READ AND WRITE INPUT DATA SET
C           (B) STORE NOMINAL COMMON BLOCK VALUES TO A TEMPORARY DATA SE
C         06/15/72  D. BUSHI, C&S INC
C         UPDATE TO CALL THE EARLY ORBIT PROGRAM
C         AUGUST 1, 1972  J.FEIN  COMPUTER SCIENCES CORPORATION
C         A)  CALL DSPEXC(DATA SIMULATION PROGRAM) INSTEAD OF DOGGON
C     09/14/72 J. E. DUNN, JR., COMPUTER SCIENCES CORPORATION
C        (A) ADDED PAGING CONTROL FOR PRINT-OUT
C        (B) MODIFIED ERROR PROCESSING LOGIC
C        (C) ADDED CALL TO WRKREP AFTER WFCONT CALL
C         10/12/72 J. E. DUNN, JR., COMPUTER SCIENCES CORPORATION
C            (A) DELETED WRITE OF COMMON BLOCK EDIT
C            (B) DELETED COMMON BLOCK EDIT
```

```
C          (C) DELETED COMMON BLOCK WORKER
C     MODIFIED ON JAN 25,1973              E. JAHN, CSC
C        IMPLEMENT CRT INPUT MODE
C         10/27/72  D. BUSHI, C&S INC
C           (A) UPDATE TO CALL THE EPHEMERIS COMPARISON PROGRAM
C         NOV 1972 BY ANN WELKER , C S C
C         A) ADD CALCULATIONS FOR TEST MODE
C     MODIFIED ON MARCH 25,1973      E. JAHN, C.S.C.
C         CHANGE CALLING SEQUENCE TO CRTIN
C     MODIFIED ON OCTOBER 25,1973 BY E. JAHN,     C.S.C.
C        REMOVE INTERNAL WRITES..CALL ERROUT
C
C
      IMPLICIT         REAL*8 (A-H,O-Z)
                       LOGICAL*1 LOGDCP     ,LSTA
C
      COMMON/DCFL   / DPDFL(2425)
      COMMON/DCINPT/ DPDCP (300)          ,INTDCP(200)          ,LOGDCP(72)
      COMMON/DCINT  / DPDCI  (432)        ,INTDCI( 26)
      COMMON/FRC    / DPFRC(1300)         ,INTFRC( 38)
      COMMON/INTEG  / DPINT  (149)        ,INTINT(  2)
      COMMON/SATMAN/ DPSTM  (164)         ,INTSTM(10)
      COMMON/SATPOS/ DPSTP  (100)         ,INTSTP(  6)
      COMMON/SCOPE  /IGSP         ,NO      ,I2250     ,IATL      ,IGDS(14),
     *               ISCOPE    ,NOBSD
      COMMON/SECTN  / DPSEC  (675)        ,INTSEC(325)
      COMMON/SLPOPT/ DPSLP  (   1)        ,INTSLP( 12)
      COMMON/STAGE0/ DPSTA(435)           ,INTSTA(182)          ,LSTA(80)
      COMMON/TITLE  / HEADER(9,6)             ,MODWF(6)
      COMMON/FILES  / INFILE(100)
      COMMON/SWITCH/ INSW(200)
C
      DIMENSION       XTO(3)     ,XDTO(3)   ,IREC(10)
      DIMENSION       CARD(10)
C
      EQUIVALENCE     (NOUT                ,INFILE(22)                  ),
     *                (NOPTS               ,INFILE(21)                  ),
     *                (NOIDS               ,INFILE(57)                  ),
     *                (IND48               ,INSW  (48)                  ),
     *                (IEOF                ,INSW(164)                   ),
     *                (NBRRUN              ,INSW(171)                   ),
     *                (NBRDC               ,INSW(172)                   ),
     *                (IPRMPT              ,INSW(175)                   )
       EQUIVALENCE    (NBNOM               ,INFILE(72)),
     *                (NBTST               ,INFILE(73))
      EQUIVALENCE     (IPASWD              ,INSW(190)),
     *                (ITSTR               ,INSW(189))
      EQUIVALENCE     (XTO(1)              ,DPDCI(1)                    ),
     *                (XDTO(1)             ,DPDCI(4)                    ),
     *                (RMS                 ,DPDFL(1675)                 )
      EQUIVALENCE     (POSN                ,IREC(1)),
```

```
     *                  (VELN                  ,IREC(3)),                          64250104
     *                  (RMSS                  ,IREC(5)),                          64250105
     *                  (SPR1                  ,IREC(7)),                          64250106
     *                  (SPR2                  ,IREC(9))                           64250107
      DATA SPR1,SPR2 /0. , 0./                                                     64250108
C                                                                                  64250109
      INSW(45)=2                                                                   64250110
      NERR = 0                                                                     64250111
      IPRMPT =2                                                                    64250112
      INSW(183)=1                                                                  64250113
      ISCOPE=2                                                                     64250114
C     CALL CKSCOP TO SET FLAGS IF SCOPE IS AVAILABLE                               64250115
      CALL CKSCOP                                                                  64250116
C     CALL SUBROUTINE SETDAF TO SUPPLY FORTRAN I/O SUBROUTINES WITH                64250117
C     INFORMATION DESCRIBING THE DIRECT ACCESS DATA SETS                           64250118
C                                                                                  64250119
   10 CALL SETDAF                                                                  64250120
              * 8 Fortran statement deleted                                        64250132
                                                                                   64250133
C     WRITE NOMINAL COMMON BLOCK VALUES TO DATA SET                                64250134
C                                                                                  64250135
      WRITE(NOIDS)      DPDCP      ,INTDCP    ,LUGDCP    ,DPDCI     ,INTDCI      ,64250136
     *                  DPFRC      ,INTFRC    ,                                    64250137
     *                  DPINT      ,INTINT    ,DPSTM     ,INTSTM    ,              64250138
     *                  DPSTP      ,INTSTP    ,DPSEC     ,INTSEC    ,              64250139
     *                  DPSLP      ,INTSLP    ,DPSTA     ,INTSTA    ,LSTA        ,64250140
     *                  HEADER     ,MODWF     ,INSW                                64250141
      REWIND NOIDS                                                                 64250142
```

Remaining Subroutine 'ODSEXEC'

```
/*
//STEP2   EXEC PGM=IEWL,PARM='LET,LIST,MAP,OVLY,NCAL,SIZE=(240K,48K)',
//        COND=(5,LT),TIME=(0,30),REGION=252K
//NEWLIN    DD DUMMY
//TAPELIB   DD DUMMY,DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//LOADLIB   DD DUMMY
//MYLIB   DD   DSN=ORBGEN.GTDS.LOMODUL,DISP=SHR
//SYSUT1 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(CYL,(2,1))
//LKED.SYSLIB DD DSNAME=SYS1.FORTLIB,DISP=SHR
//               DD DSNAME=SYS2.FORTSSP,DISP=SHR
//SYSPRINT   DD   SYSOUT=A,DCB=(LRECL=120,RECFM=FBA,BLKSIZE=600)
//SYSLMOD DD UNIT=USERDA,DISP=(NEW,CATLG),
//        DSN=ORBGEN.GTDS.NEWLOAD(MAIN),SPACE=(CYL,(1,1,1))
//LKED.SYSLIN DD DSNAME=*.STEP1.CMP.SYSLIN,DISP=(OLD,DELETE)
//  DD  *  To include object deck to open Units 1-99.
```

* Changes made to suit OSU Computer System.

```
ENTRY MAIN                                                          OVLY    2
 REPLACE BLKLET,PLTDMP,QUICKY,TYPLIN,UCS,TYPWRITE                   OVLY    4
INCLUDE  TAPELIB                                                    OVLY    6
REPLACE RTOBS,VPFORC,GOFUNO,GO24,SELRUN                             OVLY    8
*INCLUDE MYLIB(GTDS)
OVERLAY REG1SEG1                                                    OVLY   12
INSERT READER,IHCSLOG,IHCSSCN,IHCFRXPI,IHCFRXPR,IHCSEXP,GSCALE,CPLOT$ OVLY 14
 INSERT DATE,EDITT,GRID,GRDNUM,HORLIN,MINT,PLOTST,SCHAR,SC4020,TIMING OVLY 16
OVERLAY  REG1SEG1                                                   OVLY   18
INSERT   ORBIT,INTP                                                 OVLY   20
INSERT   WORKER,HEMITR,TIMREG,VCROSS                                OVLY   22
OVERLAY  REG1SEG2                                                   OVLY   24
INSERT  FORCES,DPART,SECHEK,SECUPD,DFIX,INV2,OSMEAN,BRWORB,DKEPLR    OVLY   26
OVERLAY  REG1SEG3                                                   OVLY   28
INSERT  ORBITB,RESINB,INTOGA,BROCOR                                 OVLY   30
OVERLAY  REG1SEG3                                                   OVLY   32
INSERT         CSHAD,AERO,DRAGV,FAPX,FORCV,HARMON,HARMV,HEIGHT      OVLY   34
INSERT       PMASS,PMASSV,SECHKN,SLRADV,SOLRAD,SPART,MANEUV         OVLY   36
INSERT   SUMS,TESTH,TWOBDY,VARFRC,RESUME,SPARTV                     OVLY   38
INSERT  GMTRA,TOBODY                                                OVLY   40
INSERT ANPART,BURN,BURNV,SCATT,TKPTC                                OVLY   42
OVERLAY REG1SEG4                                                    OVLY   44
INSERT COVUP,SOLTAB,GVCVL,SYMINV                                    OVLY   46
OVERLAY REG1SEG4                                                    OVLY   48
INSERT LG5,PARTE                                                    OVLY   50
OVERLAY REG1SEG4                                                    OVLY   52
INSERT ATMOS                                                        OVLY   54
OVERLAY REG1SEG4                                                    OVLY   56
INSERT JACROB,DRAGCN                                                OVLY   58
OVERLAY REG1SEG5                                                    OVLY   60
INSERT LOWALT,ROOTS                                                 OVLY   62
OVERLAY REG1SEG6                                                    OVLY   64
INSERT DIFFDE                                                       OVLY   66
OVERLAY REG1SEG6                                                    OVLY   68
INSERT BARODE                                                       OVLY   70
OVERLAY REG1SEG5                                                    OVLY   72
INSERT HIALT,JACCWF                                                 OVLY   74
OVERLAY  REG1SEG2                                                   OVLY   76
INSERT   GETHDR,ORBITF,INTOGF,ERRGET                                OVLY   78
OVERLAY  REG1SEG3                                                   OVLY   80
INSERT   GREC1,OUTEC1                                               OVLY   82
INSERT CMPVCT,GREC2,OUTEC2                                          OVLY   84
OVERLAY  REG1SEG3                                                   OVLY   86
INSERT DSPING,DSPCBK,DSPFL,TPSCHL                                   OVLY   88
OVERLAY REG1SEG4                                                    OVLY   90
INSERT INTDEP,OUTDS1,EVENT,GETDSP,GRDS1                             OVLY   92
OVERLAY REG1SEG4                                                    OVLY   94
INSERT DSPSUM,GAUSS,DODSWR,OUTDS2,SCHDUL,NOCCLT,RANDU               OVLY   96
OVERLAY REG1SEG4                                                    OVLY   98
INSERT OUTDS3,GDSSUM,STARPT,BCD                                     OVLY  100
OVERLAY  REG1SEG1                                                   OVLY  102
INSERT WFCONT                                                       OVLY  104
OVERLAY REG1SEG2                                                    OVLY  106
```

* Member 'GTDS' as obtained from GSFC.

```
INSERT IRWF,IONGEN,SOLGET,REFGEN,MAGFRT,SICORT,DKSIRT,GKRT            OVLY 108
INSERT DKGKRT,IGETRT,COEFF1                                           OVLY 110
INSERT IRWCSC,COEF1,NBSDAT                                            OVLY 112
OVERLAY  REG1SEG2                                                     OVLY 114
INSERT DODSEL,ELSWF,ELSGET                                            OVLY 116
INSERT ATMWF,ICWF,MANWF,PCWF,SECWF,SETLIF                             OVLY 118
OVERLAY  REG1SEG2                                                     OVLY 120
INSERT OBSWF,REJRPT                                                   OVLY 122
OVERLAY  REG1SEG3                                                     OVLY 124
INSERT   REFRMT,DWRITE,UPSTAT,OBSCRD,SELCON,DODSDT                    OVLY 126
INSERT   DODSOB,GEOWF,USBOBS,PCERD,GEOCON,GETGEO                      OVLY 128
OVERLAY  REG1SEG3                                                     OVLY 130
   INSERT SORTIT,SORTOB,SORTB                                         OVLY 132
OVERLAY  REG1SEG2                                                     OVLY 134
INSERT   SLPEPH                                                       OVLY 136
INSERT   AMATRX,CMATRX,GETTAP,INPUT1,CHEBY,READE,SLPTAP               OVLY 138
INSERT   CETBL1,CETBL3,CETBL4,CETBL9,SAVE,INPUT,SLPWF,CHEV            OVLY 140
OVERLAY  REG1SEG4(REGION)                                             OVLY 142
INSERT   CROSSV,RESINV,MULSTP,USER,USE,ORBITV                         OVLY 144
OVERLAY REG1SEG5                                                      OVLY 146
INSERT   INARRY,DPX2EL                                                OVLY 148
OVERLAY REG1SEG5                                                      OVLY 150
INSERT CETODS                                                         OVLY 152
OVERLAY REG1SEG5                                                      OVLY 154
INSERT ASCOEF,IBINC,RESWRV,APPSUM                                     OVLY 156
INSERT PARCOR                                                         OVLY 158
OVERLAY REG1SEG5                                                      OVLY 160
INSERT  CSTEPX,EQUMTN,AVRAGE,INTPAR                                   OVLY 162
OVERLAY REG1SEG6                                                      OVLY 164
INSERT   DPEL2X,FUNCTE                                                OVLY 166
OVERLAY REG1SEG6                                                      OVLY 168
INSERT        PERFOR,CAPEFO,COMATD,FIDPAR,HEMIDS,DSTOCE               OVLY 170
OVERLAY REG1SEG6                                                      OVLY 172
INSERT EQUNPV,PARTEQ,AVSTRT,GOFUN,VOQUAD                              OVLY 174
OVERLAY REG1SEG6                                                      OVLY 176
INSERT DQRTIC,DCUBIC                                                  OVLY 178
OVERLAY REG1SEG6                                                      OVLY 180
INSERT   IDLPV,IPART                                                  OVLY 182
OVERLAY REG1SEG6                                                      OVLY 184
INSERT   DALLPV,PARDT                                                 OVLY 186
OVERLAY REG1SEG5                                                      OVLY 188
INSERT ISTART                                                         OVLY 190
OVERLAY REG1SEG5                                                      OVLY 192
INSERT   IDEAL,CNVPV                                                  OVLY 194
OVERLAY  REG1SEG4                                                     OVLY 196
INSERT  SETORB,SATTIP,AEROPR                                          OVLY 198
OVERLAY  REG1SEG4                                                     OVLY 200
INSERT   ORBITT,COPS,CROSST,CHIRP,VARARR,CO,EVA,EVAPT,INTEGT          OVLY 202
INSERT CHETO,TCTP,PDP,EATRAN,CHVTP                                    OVLY 204
OVERLAY  REG1SEG5                                                     OVLY 206
INSERT   RESNTT                                                       OVLY 208
OVERLAY  REG1SEG5                                                     OVLY 210
INSERT   RESWMT                                                       OVLY 212
OVERLAY  REG1SEG4                                                     OVLY 214
INSERT   INTOGN,NEPOCH,HARM                                           OVLY 216
```

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OVERLAY  REG1SEG4                                                    OVLY 218
INSERT ORBINT                                                        OVLY 220
OVERLAY  REG1SEGA                                                    OVLY 222
INSERT   CROSSR,EQMOTR,ORBITR                                        OVLY 224
OVERLAY  REG1SEG5                                                    OVLY 226
INSERT   RESINR,RKS8R                                                OVLY 228
OVERLAY  REG1SEG5                                                    OVLY 230
INSERT   CSTEPR,RSWRMR                                               OVLY 232
OVERLAY  REG1SEGA                                                    OVLY 234
INSERT   ORBITC,RKG4                                                 OVLY 236
OVERLAY  REG1SEGB                                                    OVLY 238
INSERT NEWTAB                                                        OVLY 240
INSERT   CSTEP                                                       OVLY 242
OVERLAY  REG1SEGB                                                    OVLY 244
INSERT  CROSSC,RESINC                                                OVLY 246
OVERLAY  REG1SEG5                                                    OVLY 248
INSERT   XSUM                                                        OVLY 250
OVERLAY REG1SEG6                                                     OVLY 252
INSERT   MSTART,XCOR,XDCOR                                           OVLY 254
OVERLAY REG1SEG6                                                     OVLY 256
INSERT   RESWRM                                                      OVLY 258
OVERLAY REG1SEG5                                                     OVLY 260
INSERT RKS8                                                          OVLY 262
OVERLAY  REG1SEG4                                                    OVLY 264
  INSERT RPDATO                                                      OVLY 266
OVERLAY  REG1SEG5                                                    OVLY 268
INSERT RUNACC,STADRO,OUTDC6                                          OVLY 270
OVERLAY  REG1SEG5                                                    OVLY 272
INSERT SCAN,UPCOV,GETORN,SCALE                                       OVLY 274
OVERLAY  REG1SEG4                                                    OVLY 276
INSERT EOFLTR                                                        OVLY 278
OVERLAY  REG1SEG5                                                    OVLY 280
INSERT EGAUSS                                                        OVLY 282
OVERLAY  REG1SEG5                                                    OVLY 284
INSERT DOUBLR                                                        OVLY 286
OVERLAY  REG1SEG5                                                    OVLY 288
INSERT POSFIX                                                        OVLY 290
OVERLAY  REG2SEG1(REGION)                                            OVLY 292
INSERT   NOREST,RESTAT,GRDCO                                         OVLY 294
OVERLAY  REG2SEGH                                                    OVLY 296
INSERT ANTRA,OBS,OBSCOR,OBSP,OBSRD,READWF,SORREG,TRANF,OBSUSB,OBSUS1 OVLY 298
INSERT   TRUANO,WEIGHT,OUTDC5,IBPNT,CNVPCK,MA1333,OBSED,ICONVO,ITERCT OVLY 300
OVERLAY REG2SEG3                                                     OVLY 302
INSERT CORDBA,LCLARG                                                 OVLY 304
INSERT ION,BETA,COEFF2,MODEL                                         OVLY 306
OVERLAY REG2SEG5                                                     OVLY 308
INSERT PRFLPF,MAGFIN,SICOJT,DKSICO,GK,DKGK,IONGET                    OVLY 310
INSERT TROPOA,TROGET,F,ASC                                           OVLY 312
OVERLAY REG2SEG5                                                     OVLY 314
INSERT  PRFLRT,INTERP,REFGET,TABLES                                  OVLY 316
OVERLAY REG2SEG3                                                     OVLY 318
INSERT CORCSC,REFCON,IONOSP,SZZ,VCROSW                               OVLY 320
OVERLAY  REG2SEGH                                                    OVLY 322
INSERT   IHCLSCNH,INVL                                               OVLY 324
```

```
INSERT   OUTPUT,SPAT,ELEME,ROTRAN,KPART,PPART,CELEM,POLAR,SCART,ROT     OVLY 326
INSERT CAIRS                                                            OVLY 328
OVERLAY  REG2SEG2                                                       OVLY 330
INSERT      OUTDC4,OUTDC3,OUTDC7,OUTDC2,OUTDC8                          OVLY 332
OVERLAY  REG2SEG2                                                       OVLY 334
INSERT ORBOUT,OBOUT2,GROEFI,CONSC2,OUTLIF,DIFD,MINSTR,SHORTP            OVLY 336
INSERT   EPHEM                                                          OVLY 338
INSERT   ORB1                                                           OVLY 340
OVERLAY REG2SEG2                                                        OVLY 342
INSERT W24WF,OBSAVE                                                     OVLY 344
OVERLAY  REG2SEG2                                                       OVLY 346
INSERT   ADVANS                                                         OVLY 348
OVERLAY REG2SEGA                                                        OVLY 350
INSERT GRDCRS,COMPER                                                    OVLY 352
OVERLAY REG2SEG3                                                        OVLY 354
INSERT GRDCI,IHCFMAXI                                                   OVLY 356
OVERLAY REG2SEG4                                                        OVLY 358
INSERT GRSLVA                                                           OVLY 360
OVERLAY REG2SEG4                                                        OVLY 362
INSERT GREDIT                                                           OVLY 364
OVERLAY REG2SEG3                                                        OVLY 366
INSERT   GREPAD                                                         OVLY 368
OVERLAY REG2SEG3                                                        OVLY 370
INSERT GRPEL                                                            OVLY 372
OVERLAY REG2SEG3                                                        OVLY 374
INSERT GR24HH                                                           OVLY 376
OVERLAY REG2SEG3                                                        OVLY 378
INSERT GRDCON                                                           OVLY 380
OVERLAY REG2SEG3                                                        OVLY 382
INSERT GRBIAS                                                           OVLY 384
OVERLAY  REG2SEGA                                                       OVLY 386
INSERT   INTDC,EIGEN,CHIN,SOLVGP                                        OVLY 388
OVERLAY  REG2SEG3                                                       OVLY 390
INSERT   SLOBT,CONDR                                                    OVLY 392
OVERLAY  REG2SEG3                                                       OVLY 394
INSERT   OUTDC1,OUTOG1                                                  OVLY 396
OVERLAY  REG2SEG4                                                       OVLY 398
 INSERT OUTSLV,OUTCOR                                                   OVLY 400
OVERLAY  REG2SEG4                                                       OVLY 402
 INSERT OUTEDT,OUTOUT,OUTSEC,OUTPHC,OGCROS                              OVLY 404
OVERLAY  REG2SEG4                                                       OVLY 406
 INSERT OUTCRD,OUTGEN,OUTTIC                                            OVLY 408
OVERLAY  REG2SEG2                                                       OVLY 410
INSERT PSET,MATCON,ELSIG,ELSIG1,PPLHXY                                  OVLY 412
OVERLAY  REG2SEG2                                                       OVLY 414
INSERT GRREPT,GRDC2,GRPROM,FDORB                                        OVLY 416
OVERLAY  REG2SEG2                                                       OVLY 418
INSERT GRPMEN,GENONE,GENTWO,GRSORT,IHCGSP04,WAIT,GRPLOT,GRTRAK          OVLY 420
OVERLAY  REG2SEG2                                                       OVLY 422
INSERT   IGRAPH,IGRPH2                                                  OVLY 424
OVERLAY REG2SEG1                                                        OVLY 426
INSERT GETCMP,CMPOPT,PLOTTP                                             OVLY 428
OVERLAY  REG2SEG1                                                       OVLY 430
INSERT   OUTSG,PLHXYZ                                                   OVLY 432
```

```
OVERLAY  REG2SEG2                                                    OVLY 434
INSERT   WRKREP                                                      OVLY 436
INSERT   OUTWAD,OUTWEL,OUTWIC,OUTWMN,OUTWPC,OUTWSC,OUTWIR,OUTWOB     OVLY 438
INSERT   OUTWSL,OUTWTC                                               OVLY 440
OVERLAY  REG2SEG2                                                    OVLY 442
INSERT   PERCON                                                      OVLY 444
INSERT   OUTPAD,OUTPEL,OUTPIC,OUTPIR,OUTPOB,OUTPPC,OUTPSL            OVLY 446
INSERT   OUTPTC,OUT24H,OUTPMN,OUTPSC                                 OVLY 448
OVERLAY  REG3SEG1(REGION)                                            OVLY 450
INSERT   EPHGEN                                                      OVLY 452
OVERLAY  REG3SEG2                                                    OVLY 454
INSERT   OUTOG2,OUTOG3,OUTOG4,OUTPAR,PRINT,UNIT,OUTMAP               OVLY 456
OVERLAY  REG3SEG2                                                    OVLY 458
INSERT   ACWFRP,ADWFRP,EPWFRP,FSWFRP,IGRPH2,LPWFRP,OGMENU            OVLY 460
OVERLAY  REG3SEG2                                                    OVLY 462
INSERT   OGBUG                                                       OVLY 464
OVERLAY  REG3SEG1                                                    OVLY 466
INSERT EPHCMP,RDORB1,ADDYMD,ADTIME                                   OVLY 468
OVERLAY  REG3SEG1                                                    OVLY 470
INSERT   DCING,DCFL,DCBUG,STAGE1                                     OVLY 472
OVERLAY  REG3SEG2                                                    OVLY 474
INSERT   DC,ITERCT                                                   OVLY 476
OVERLAY  REG3SEG2                                                    OVLY 478
INSERT   DSPEXC                                                      OVLY 480
OVERLAY REG3SEG1                                                     OVLY 482
INSERT GRERR,DUMPER                                                  OVLY 484
OVERLAY  REG3SEG1                                                    OVLY 486
INSERT   SETRUN,MSGWTR,OKERR,CKSCOP                                  OVLY 488
OVERLAY  REG3SEG2                                                    OVLY 490
INSERT   SETANL                                                      OVLY 492
OVERLAY  REG3SEG2                                                    OVLY 494
INSERT   SETCMP                                                      OVLY 496
OVERLAY  REG3SEG2                                                    OVLY 498
INSERT   SETDC                                                       OVLY 500
OVERLAY  REG3SEG2                                                    OVLY 502
INSERT   SETDM,DIFF                                                  OVLY 504
OVERLAY  REG3SEG2                                                    OVLY 506
INSERT  SETRPT,SETPER                                                OVLY 508
OVERLAY REG3SEG2                                                     OVLY 510
INSERT CRTIN,GRCARD,RDPDS,CSTAE,INTGR                                OVLY 512
OVERLAY REG3SEG1                                                     OVLY 514
INSERT EARLYO,SECULA,RANGLE,EO,ELEMGN,ANGLES,POLRT                   OVLY 516
/*
//GO  EXEC PGM=MAIN,TIME=(5,00),REGION=504K
//STEPLIB  DD  DSN=ORBGEN.GTDS.NEWLOAD,DISP=SHR *
//GO.FT01F001  DD  DSN=ORBGEN.GTDS.DIRECTRY.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT02F001   DD  DSN=ORBGEN.GTDS.ATMOSDEN.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
```

* New Partition Data Set as created in Step 2 and Member name changed to 'MAIN.'

```
//GO.FT03F001    DD   DSN=ORBGEN.GTDS.MANEUVER.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT04F001    DD   DSN=ORBGEN.GTDS.ASTROCON.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT06F001    DD   SYSOUT=A
//GO.FT07F001    DD   SYSOUT=B
//GO.FT08F001    DD   DSN=ORBGEN.GTDS.EARTHFLD.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT09F001    DD   DSN=ORBGEN.GTDS.LUNARFLD.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT10F001    DD   DSN=ORBGEN.GTDS.INTCOEF.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT11F001    DD   DSN=ORBGEN.GTDS.SECTIONS.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT13F001    DD   DSN=ORBGEN.GTDS.ERRORMSG.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT14F001    DD   DSN=ORBGEN.GTDS.SLP1950.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT16F001    DD   UNIT=USERDA,SPACE=(TRK,(1,6)),
//         DCB=(RECFM=VBS,LRECL=124,BLKSIZE=3352,DSORG=DA,BUFNO=1)
//GO.FT17F001    DD   UNIT=USERDA,SPACE=(CYL,4),
//         DCB=(DSORG=DA,BUFNO=1)
//GO.FT18F001    DD UNIT=USERDA,SPACE=(3520,12),DCB=(DSORG=DA,BUFNO=1)
//GO.FT20F001 DD DSN=&&ORBT,DISP=(NEW,PASS),UNIT=USERDA,
//         SPACE=(1092,240),DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1)
//GO.FT22F001 DD DSN=&&ORBF,SPACE=(CYL,(5,1)),
//         UNIT=USERDA,DISP=(NEW,PASS)
//GO.FT24F001    DD UNIT=USERDA,SPACE=(TRK,(1,20)),
//         DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)
//GO.FT25F001    DD   DSN=ORBGEN.GTDS.ELEMENTS.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT26F001    DD   DSN=ORBGEN.GTDS.D24HOUR.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT27F001    DD   DSN=ORBGEN.GTDS.GEODTICS.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT30F001 DD DSN=&&FMOBS,UNIT=USERDA,
//          DISP=(NEW,PASS),SPACE=(CYL,(5,1))
//GO.FT38F001    DD   DSN=ORBGEN.GTDS.TIMCOF.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT39F001    DD   DSN=ORBGEN.GTDS.GENCOF.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT59F001    DD   DSN=ORBGEN.GTDS.SOLDAT.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT60F001    DD   DSN=ORBGEN.GTDS.ACCOUNT.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT68F001    DD   DSN=ORBGEN.GTDS.TRODAT.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT75F001    DD   DSN=ORBGEN.GTDS.JACCHIA.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT05F001    DD   *
/*
//
```

Note: The JCLs in "GO" Step would require changes according to a different job (see Attachment 6 also).

```
//        (8000,5000),CLASS=D
//STEP1   EXEC  PROC=FORTRANG,PARM='MAP,ID',TIME.CMP=(0,15)
//CMP.SYSIN  DD  *
```

Subroutines to be Modified or Added

```
/*
//STEP2   EXEC PGM=IEWL,PARM='LET,LIST,MAP,OVLY,NCAL,SIZE=(240K,48K)',
//        COND=(5,LT),TIME=(0,30),REGION=252K
//NEWLIN    DD DUMMY
//TAPELIB  DD DUMMY,DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//LOADLIB  DD DUMMY
//MYLIB   DD   DSN=ORBGEN.GTDS.NEWLOAD,DISP=SHR
//SYSUT1 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(CYL,(2,1))
//LKED.SYSLIB DD DSNAME=SYS1.FORTLIB,DISP=SHR
//               DD DSNAME=SYS2.FORTSSP,DISP=SHR
//SYSPRINT   DD   SYSOUT=A,DCB=(LRECL=120,RECFM=FBA,BLKSIZE=600)
//SYSLMOD DD DSNAME=&GO(MAIN),UNIT=SYSDA,SPACE=(CYL,(1,1,1)),
//          DISP=(NEW,PASS)
//LKED.SYSLIN DD DSNAME=*.STEP1.CMP.SYSLIN,DISP=(OLD,DELETE)
//  DD  *
```

Object Deck and Overlay Structure from Attachment 4

Note: In statement 'Include MyLib(GTDS)', member name would now be punched as 'MAIN.'

```
//GO  EXEC PGM=*.STEP2.SYSLMOD,TIME=(04,10),REGION=504K
//GO.FT01F001    DD   DSN=ORBGEN.GTDS.DIRECTRY.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT02F001    DD   DSN=ORBGEN.GTDS.ATMOSDEN.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT03F001    DD   DSN=ORBGEN.GTDS.MANEUVER.DATA,
```

```
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT04F001    DD   DSN=ORBGEN.GTDS.ASTROCON.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT06F001    DD   SYSOUT=A
//GO.FT07F001    DD   SYSOUT=B
//GO.FT08F001    DD   DSN=ORBGEN.GTDS.EARTHFLD.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT09F001    DD   DSN=ORBGEN.GTDS.LUNARFLD.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT10F001    DD   DSN=ORBGEN.GTDS.INTCOEF.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT11F001    DD   DSN=ORBGEN.GTDS.SECTIONS.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT13F001    DD   DSN=ORBGEN.GTDS.ERRORMSG.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT14F001    DD   DSN=ORBGEN.GTDS.SLP1950.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT16F001    DD   UNIT=USERDA,SPACE=(TRK,(1,6)),
//         DCB=(RECFM=VBS,LRECL=124,BLKSIZE=3352,DSORG=DA,BUFNO=1)
//GO.FT17F001    DD   UNIT=USERDA,SPACE=(CYL,4),
//         DCB=(DSORG=DA,BUFNO=1)
//GO.FT18F001   DD UNIT=USERDA,SPACE=(3520,12),DCB=(DSORG=DA,BUFNO=1)
//GO.FT20F001 DD DSN=&&ORBT,DISP=(NEW,PASS),UNIT=USERDA,
//         SPACE=(1092,240),DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1)
//GO.FT22F001 DD DSN=&&ORBF,SPACE=(CYL,(5,1)),
//         UNIT=USERDA,DISP=(NEW,PASS)
//GO.FT24F001    DD UNIT=USERDA,SPACE=(TRK,(1,20)),
//         DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1)
//GO.FT25F001    DD   DSN=ORBGEN.GTDS.ELEMENTS.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT26F001    DD   DSN=ORBGEN.GTDS.D24HOUR.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT27F001    DD   DSN=ORBGEN.GTDS.GEODTICS.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT30F001 DD DSN=&&FMOBS,UNIT=USERDA,
//          DISP=(NEW,PASS),SPACE=(CYL,(5,1))
//GO.FT38F001    DD   DSN=ORBGEN.GTDS.TIMCOF.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT39F001    DD   DSN=ORBGEN.GTDS.GENCOF.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT59F001    DD   DSN=ORBGEN.GTDS.SOLDAT.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT60F001    DD   DSN=ORBGEN.GTDS.ACCOUNT.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT68F001    DD   DSN=ORBGEN.GTDS.TRUDAT.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT75F001    DD   DSN=ORBGEN.GTDS.JACCHIA.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT05F001    DD   *
/*
//
```

```
//     (05500,5000),CLASS=D,REGION=504K
/*SETUP          UNIT=TAPE9,ID=(,I056,WRITE,COGEOS)
/*SETUP          UNIT=TAPE9,ID=(,J158,WRITE,CLGS29)
//GO  EXEC  PGM=MAIN,TIME=(9,45)
//STEPLIB  DD  DSN=ORBGEN.GTDS.NEWLOAD,DISP=SHR
//GO.FT01F001    DD   DSN=ORBGEN.GTDS.DIRECTRY.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT02F001    DD   DSN=ORBGEN.GTDS.ATMOSDEN.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT03F001    DD   DSN=ORBGEN.GTDS.MANEUVER.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT04F001    DD   DSN=ORBGEN.GTDS.ASTROCON.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT06F001    DD   SYSOUT=A
//GO.FT07F001    DD   SYSOUT=B
//GO.FT08F001    DD   DSN=ORBGEN.GTDS.EARTHFLD.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT09F001    DD   DSN=ORBGEN.GTDS.LUNARFLD.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT10F001    DD   DSN=ORBGEN.GTDS.INTCOEF.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT11F001    DD   DSN=ORBGEN.GTDS.SECTIONS.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT13F001    DD   DSN=ORBGEN.GTDS.ERRORMSG.DATA,
//         UNIT=3330,VOL=SER=IRCC74,DISP=SHR
//GO.FT14F001    DD   DSN=ORBGEN.GTDS.SLP1950.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT16F001    DD   UNIT=USERDA,SPACE=(CYL,(1,1)),
//         DCB=(RECFM=VBS,LRECL=124,BLKSIZE=3352,DSORG=DA,BUFNO=1)
//GO.FT17F001    DD   UNIT=USERDA,SPACE=(CYL,(4,1)),
//         DCB=(DSORG=DA,BUFNO=1)
//GO.FT18F001  DD UNIT=USERDA,SPACE=(3520,12),DCB=(DSORG=DA,BUFNO=1)
//GO.FT19F001  DD  UNIT=USERDA,SPACE=(6660,240),
//   DCB=(RECFM=F,BLKSIZE=6660,DSORG=DA,BUFNO=1)
//GO.FT20F001 DD DSN=&&ORBT,DISP=(NEW,PASS),UNIT=USERDA,
//         SPACE=(1092,240),DCB=(RECFM=F,BLKSIZE=1092,DSORG=DA,BUFNO=1)
//GO.FT22F001 DD DSN=&&ORBF,SPACE=(CYL,(5,1)),
//         UNIT=USERDA,DISP=(NEW,PASS)
//GO.FT24F001    DD UNIT=TAPE9,LABEL=(1,BLP),DISP=(OLD,KEEP),
// DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1),VOL=(PRIVATE,RETAIN,SER=COGEOS)
//GO.FT25F001    DD   DSN=ORBGEN.GTDS.ELEMENTS.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT26F001    DD   DSN=ORBGEN.GTDS.D24HOUR.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT27F001    DD   DSN=ORBGEN.GTDS.GEODTICS.DATA,
//         UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT29F001 DD DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408,BUFNO=1),
// UNIT=TAPE9,LABEL=(,BLP),DISP=SHR,VOL=(PRIVATE,RETAIN,SER=CLGS29)
//GO.FT30F001 DD DSN=&&FMOBS,UNIT=USERDA,
//  DISP=(NEW,PASS),SPACE=(CYL,(5,1))
//GO.FT31F001 DD  UNIT=USERDA,DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408),
//    DISP=(NEW,PASS).SPACE=(CYL,(1,1))
```

```
//GO.FT37F001 DD DSN=&SORT,UNIT=USERDA,SPACE=(CYL,(2,1)),
//   DCB=(RECFM=VBS,LRECL=148,BLKSIZE=3408,BUFNO=1),DISP=(NEW,PASS)
//GO.FT38F001    DD   DSN=ORBGEN.GTDS.TIMCOF.DATA;
//        UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT39F001    DD   DSN=ORBGEN.GTDS.GENCOF.DATA,
//        UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT45F001   DD   UNIT=USERDA,SPACE=(TRK,(10,1)),DISP=SHR,
//     VOL=REF=*.GO.FT17F001
//GO.FT46F001 DD LABEL=(2,BLP),DISP=SHR,VOL=REF=*.GO.FT29F001,
// DCB=(RECFM=VS,BLKSIZE=928,BUFNO=1)
//GO.FT47F001   DD   UNIT=USERDA,SPACE=(CYL,(01,1)),DISP=SHR,
//     VOL=REF=*.GO.FT31F001
//GO.FT53F001   DD   UNIT=USERDA,DCB=(RECFM=FB,LRECL=80,BLKSIZE=800),
//     DISP=(NEW,PASS),SPACE=(CYL,(1,1))
//GO.FT57F001   DD   UNIT=USERDA,SPACE=(TRK,(10,10)),
//      DCB=BUFNO=1,DISP=(NEW,DELETE)
//GO.FT58F001   DD   UNIT=USERDA,SPACE=(1332,20),
//      DCB=(DSORG=DA,BUFNO=1),DSN=&&WIONO,
//     DISP=(NEW,PASS)
//GO.FT59F001    DD   DSN=ORBGEN.GTDS.SOLDAT.DATA,
//        UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT60F001    DD   DSN=ORBGEN.GTDS.ACCOUNT.DATA,
//        UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT63F001   DD   UNIT=USERDA,DCB=DSORG=DA,
//     SPACE=(CYL,(1,1)),DISP=(NEW,PASS)
//GO.FT65F001   DD   UNIT=USERDA,SPACE=(TRK,(1,20)),
//      DCB=(DSORG=DA,BUFNO=1),DSN=&&IONDAT
//GO.FT66F001   DD   DUMMY
//GO.FT67F001   DD   DUMMY
//GO.FT68F001    DD   DSN=ORBGEN.GTDS.TRODAT.DATA,
//        UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT70F001   DD   DUMMY
//GO.FT75F001    DD   DSN=ORBGEN.GTDS.JACCHIA.DATA,
//        UNIT=3330,VOL=SER=IRCC71,DISP=SHR
//GO.FT77F001   DD   UNIT=USERDA,SPACE=(TRK,(1,20)),
//      DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1),DISP=(NEW,PASS)
//GO.FT78F001   DD   DUMMY
//GO.FT81F001   DD   UNIT=USERDA,SPACE=(TRK,(1,20)),
//      DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1),DISP=(NEW,PASS)
//GO.FT82F001   DD   DUMMY
//GO.FT83F001   DD   UNIT=USERDA,SPACE=(TRK,(1,20)),
//      DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1),DISP=(NEW,PASS)
//GO.FT84F001   DD   DUMMY
//GO.FT85F001   DD   UNIT=USERDA,SPACE=(TRK,(1,20)),
//      DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1),DISP=(NEW,PASS)
//GO.FT86F001   DD   DUMMY
//GO.FT87F001   DD   UNIT=USERDA,SPACE=(TRK,(1,20)),
//      DCB=(RECFM=VS,BLKSIZE=2808,BUFNO=1),DISP=(NEW,PASS)
//GO.FT88F001   DD   DUMMY
//GO.FT91F001   DD   DUMMY
//GO.FT97F001   DD   DUMMY
//GO.FT05F001    DD   *
```

4. PERSONNEL

Ivan I. Mueller, Project Supervisor, part time

Manohar G. Arur, Graduate Research Associate, part time from 10/1/74

Athanasis Dermanis, Graduate Research Associate, part time from 10/1/74

Muneendra Kumar, Graduate Research Associate, part time from 10/1/74

Alfred Leick, Graduate Research Associate, part time

Anne S. Mason, Administrative Assistant, part time from 10/29/74

Daniel McLuskey, Graduate Research Associate, part time

Narendra K. Saxena, Research Associate, part time through 8/2/74

Tomas Soler, Graduate Research Associate, part time

Boudewijn H. W. van Gelder, Graduate Research Associate, part time from 9/1/74

5. TRAVEL

Mueller, Ivan I.
Torun (Poland) August 19 - September 7, 1974
To attend International Astronomical Union Colloquium No. 26
(partial support)

Mueller, Ivan I.
Washington, D. C. December 2 - 5, 1974
To attend Precise Time and Time Interval Planning Meeting at the
U. S. Naval Research Laboratory

Mueller, Ivan I.
San Francisco, California and Huntsville, Alabama December 12 - 18, 1974
To attend the meeting of the American Geophysical Union and to
visit NASA/MSFC to discuss LAGEOS and CLOGEOS projects

Kumar, Muneendra
Cincinnati, Ohio November 25, 1974
To visit Cincinnati Observatory for discussion with Dr. A. Deprit
regarding his Analytical Lunar Ephemeris

Kumar, Muneendra
Washington, D. C. December 29 - January 1, 1975
To visit NASA/GSFC to discuss GTDS Computer Program

McLuskey, Daniel

Washington, D. C. July 30 - August 3, 1974
To discuss computer programs with Wolf Research and Development Corporation re. preprocessing ISAGEX and WEST data

van Gelder, Boudewijn H. W.

Huntsville, Alabama December 16 - 18, 1974
To visit NASA/MSFC to discuss LAGEOS and CLOGEOS projects

6. REPORTS PUBLISHED TO DATE

OSU Department of Geodetic Science Reports published under Grant No. NSR 36-008-003:

70 The Determination and Distribution of Precise Time
by Hans D. Preuss
April, 1966

71 Proposed Optical Network for the National Geodetic Satellite Program
by Ivan I. Mueller
May, 1966

82 Preprocessing Optical Satellite Observations
by Frank D. Hotter
April, 1967

86 Least Squares Adjustment of Satellite Observations for Simultaneous Directions or Ranges, Part 1 of 3: Formulation of Equations
by Edward J. Krakiwsky and Allen J. Pope
September, 1967

87 Least Squares Adjustment of Satellite Observations for Simultaneous Directions or Ranges, Part 2 of 3: Computer Programs
by Edward J. Krakiwsky, George Blaha, Jack M. Ferrier
August, 1968

88 Least Squares Adjustment of Satellite Observations for Simultaneous Directions or Ranges, Part 3 of 3: Subroutines
by Edward J. Krakiwsky, Jack Ferrier, James P. Reilly
December, 1967

93 Data Analysis in Connection with the National Geodetic Satellite Program
by Ivan I. Mueller
November, 1967

OSU Department of Geodetic Science Reports published under Grant No. NGR 36-008-093:

100 Preprocessing Electronic Satellite Observations
by Joseph Gross
March, 1968

106 Comparison of Astrometric and Photogrammetric Plate Reduction Techniques for a Wild BC-4 Camera
by Daniel H. Hornbarger
March, 1968

110 Investigations into the Utilization of Passive Satellite Observational Data
by James P. Veach
June, 1968

114 Sequential Least Squares Adjustment of Satellite Triangulation and
Trilateration in Combination with Terrestrial Data
by Edward J. Krakiwsky
October, 1968

118 The Use of Short Arc Orbital Constraints in the Adjustment of Geodetic
Satellite Data
by Charles R. Schwarz
December, 1968

125 The North American Datum in View of GEOS I Observations
by Ivan I. Mueller, James P. Reilly, Charles R. Schwarz
June, 1969

139 Analysis of Latitude Observations for Crustal Movements
by M. G. Arur
June, 1970

140 SECOR Observations in the Pacific
by Ivan I. Mueller, James P. Reilly, Charles R. Schwarz, George Blaha
August, 1970

147 Gravity Field Refinement by Satellite to Satellite Doppler Tracking
by Charles R. Schwarz
December, 1970

148 Inner Adjustment Constraints with Emphasis on Range Observations
by Georges Blaha
January, 1971

150 Investigations of Critical Configurations for Fundamental Range Networks
by Georges Blaha
March, 1971

177 Improvements of a Geodetic Triangulation through Control-Points
Established by Means of Satellite or Precision Traversing
by Narendra K. Saxena
June, 1972

184 Coordinate Transformation by Minimizing Correlations Between Parameters
by Muneendra Kumar
July, 1972

185 On the Geometric Analysis and Adjustment of Optical Satellite Observations
by Emmanuel Tsimis
August, 1972

187 Geodetic Satellite Observations in North America (Solution NA-9)
by Ivan I. Mueller, J. P. Reilly and Tomas Soler
September, 1972

188 Free Adjustment of a Geometric Global Satellite Network (Solution MPS-7)
by Ivan I. Mueller and M. C. Whiting
October, 1972

190 The Ohio State University Geometric and Orbital (Adjustment) Program (OSUGOP) for Satellite Observations
by James P. Reilly, Charles R. Schwarz and M. C. Whiting
December, 1972

191 Critical Configurations (Determinantal Loci) for Range and Range-Difference Satellite Networks
by E. Tsimis
January, 1973

193 Free Geometric Adjustment of the DOC/DOD Cooperative Worldwide Geodetic Satellite (BC-4) Network
by Ivan I. Mueller, M. Kumar, J. Reilly and N. Saxena
February, 1973

195 Free Geometric Adjustment of the Secor Equatorial Network (Solution SECOR-27)
by Ivan I. Mueller, M. Kumar and Tomas Soler
February, 1973

196 Geometric Adjustment of the South American Satellite Densification (PC-1000) Network
by Ivan I. Mueller and M. Kumar
February, 1973

199 Global Satellite Triangulation and Trilateration for the National Geodetic Satellite Program (Solutions WN 12, 14 and 16)
by Ivan I. Mueller and M. Kumar, J. P. Reilly, N. Saxena, T. Soler
May, 1973

216 Marine Geodesy, A Multipurpose Approach to Solve Oceanic Problems
by Narendra K. Saxena
October. 1974

The following papers were presented at various professional meetings:

"Report on OSU participation in the NGSP"
47th Annual meeting of the AGU, Washington, D. C., April 1966

"Preprocessing Optical Satellite Observational Data"
3rd Meeting of the Western European Satellite Subcommission, IAG, Venice, Italy, May 1967.

"Global Satellite Triangulation and Trilateration"
XIVth General Assembly of the IUGG, Lucerne, Switzerland, September 1967, (Bulletin Geodesique, March 1968).

"Investigations in Connection with the Geometric Analysis of Geodetic Satellite Data"
GEOS Program Review Meeting, Washington, D.C., Dec. 1967.

"Comparison of Photogrammetric and Astrometric Data Reduction Results for the Wild BC-4 Camera"
Conference on Photographic Astrometric Technique, Tampa, Fla., March 1968.

"Geodetic Utilization of Satellite Photography"
7th National Fall Meeting, AGU, San Francisco, Cal., Dec. 1968.

"Analyzing Passive-Satellite Photography for Geodetic Applications"
4th Meeting of the Western European Satellite Subcommission, IAG, Paris, Feb. 1969.

"Sequential Least Squares Adjustment of Satellite Trilateration"
50th Annual Meeting of the AGU, Washington, D.C., April 1969.

"The North American Datum in View of GEOS-I Observations"
8th National Fall Meeting of the AGU, San Francisco, Cal., Dec. 1969 and GEOS-2 Review Meeting, Greenbelt, Md., June 1970 (Bulletin Geodesique, June 1970).

"Experiments with SECOR Observations on GEOS-I"
GEOS-2 Review Meeting, Greenbelt, Md., June 1970.

"Experiments with Wild BC-4 Photographic Plates"
GEOS-2 Review Meeting, Greenbelt, Md., June 1970.

"Experiments with the Use of Orbital Constraints in the Case of Satellite Trails on Wild BC-4 Photographic Plates"
GEOS-2 Review Meeting, Greenbelt, Md., June 1970.

"GEOS-I SECOR Observations in the Pacific (Solution SP-7)"
National Fall Meeting of the American Geophysical Union, San Francisco, California, December 7-10, 1970.

"Investigations of Critical Configurations for Fundamental Range Networks"
Symposium on the Use of Artificial Satellites for Geodesy, Washington, D. C., April 15-17, 1971.

"Gravity Field Refinement by Satellite to Satellite Doppler Tracking"
Symposium on the Use of Artificial Satellites for Geodesy, Washington, D. C., April 15-17, 1971.

"GEOS-I SECOR Observations in the Pacific (Solution SP-7)"
Symposium on the Use of Artificial Satellites for Geodesy, Washington, D. C., April 15-17, 1971.

"Separating the Secular Motion of the Pole from Continental Drift - Where and What to Observe?"
IAU Symposium No. 48, "Rotation of the Earth," Morioka, Japan, May 9-15, 1971.

"Geodetic Satellite Observations in North America (Solution NA-8)"
Annual Fall Meeting of the American Geophysical Union, San Francisco, California, December 6-9, 1971.

"Scaling the SAO-69 Geometric Solution with C-Band Radar Data (Solution SC 11)"
Annual Fall Meeting of the American Geophysical Union, San Francisco, California, December 6-9, 1971.

"The Impact of Computers on Surveying and Mapping"
Annual Meeting of the Permanent Committee, International Federation of Surveyors, Tel Aviv, Israel, May 1972.

"Investigations on a Possible Improvement of Terrestrial Triangulation by Means of Super-Control Points"
IAG International Symposium - Satellite and Terrestrial Triangulation, Graz, Austria, June, 1972.

"Free Adjustment of a Geometric Global Satellite Network (Solution MPS7)"
IAG International Symposium - Satellite and Terrestrial Triangulation, Graz, Austria, June, 1972.

"Conjugate Gradient Method (Cg-Method) for Geodetic Adjustments"
Annual Fall Meeting of the American Geophysical Union, San Francisco, California, December 3-6, 1972.

"Preliminary Results of the Global Satellite Triangulation Related to the NGSP"
Journees Luxembourgeoises de Geodynamique, Luxembourg, February 19-21, 1973.

"Present Status of Global Geometric Satellite Triangulation and Trilateration"
54th Annual Spring Meeting of the American Geophysical Union, Washington, D.C., April 16-20, 1973.

"Free Geometric Adjustment of the OSU/NGSP Global Network (Solution WN4)"
First International Symposium on the Use of Artificial Satellites for Geodesy and Geodynamics, Athens, Greece, May 14-21, 1973.

"Earth Parameters from Global Satellite Triangulation and Trilateration"
International Symposium on Earth's Gravitational Field and Secular Variations in Position, Sydney, Australia, November 26-30, 1973.

"Review of Problems Associated with Geodetic Datums"
International Symposium on Problems related to the Redefinition of North American Geodetic Networks, Fredericton, N.B., Canada, May 20-25, 1974.

"Marine Geodesy - Problem Areas and Solution Concepts"
International Symposium on Application of Marine Geodesy, Battelle Auditorium, Columbus, Ohio, June 3-5, 1974.

"Station Coordinates and Geodetic Datum Positions from the National Geodetic Satellite Program"
First Pan American Congress and the
Third National Congress of Photogrammetry, Photointerpretation and Geodesy, Mexico City, Mexico, July 7-12, 1974.

"Review of Classical Methods for the Determination of Geodetic Datums"
International Colloquium on Reference Coordinate Systems for Earth Dynamics (IAU Colloquium No. 26)
Torun, Poland, August 26-31, 1974.

"Global Satellite Triangulation and Trilateration Results"
Intercosmos Symposium on Results of Satellite Observations
Budapest, Hungary, October 21-24, 1974.